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FINAL REPORT D-51001
DEVELOPMENT OF COMPONENTS FOR AN
S-BAND PHASED ARRAY ANTENNA SUBSYSTEM

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ALL SUBJECT TO CHANGE

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Texas Instruments program manager for this effort was Dr. Dennis R. Delzer. Other consulting engineers were:

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	Gary Holland (Mechanical)

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Texas Instruments will welcome the opportunity to expand the technical foundation prepared by this effort. We are confident that continued development of the spacecraft antenna array described herein will lead to a useful subsystem applicable to several spacecraft uses.



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SECTION I

INTRODUCTION

This report contains the results of the second phase of the S-Band Antenna Phased Array Communications System (SPACS II) program sponsored by the Electromagnetic Systems Branch of NASA Lyndon B. Johnson Space Center under contract NAS9-14485. The system requirements, module test data, and S-band phased array subsystem test data will be discussed in this report.

Many instances of spacecraft-to-spacecraft communications (e.g., spacecraft/relay satellite and shuttle/payload) may require a medium amount of antenna gain for successful implementation. Of the two approaches to achieving antenna gain (i.e., mechanically steered reflector or electronically steered phased array), the phased array approach offers the greatest simplicity and lowest cost (size, weight, power, and dollars) for this medium gain. This report describes a competitive system design as well as hardware evaluation which will lead to timely availability of this technology for implementing such a system.

The objectives of the SPACS II contract are:

To fabricate and test six engineering model transmit/receive microelectronics modules.

To design, fabricate, and test one dc and logic multilayer manifold.

To integrate and test an S-band phased array antenna subsystem composed of antenna elements, seven T/R modules, RF manifolds and dc manifold.



The developmental requirements under this contract consisted of fabricating and testing five additional T/R modules identical to those developed under NASA contract NAS9-14196 with Johnson Space Center, developing and testing one T/R module similar to the five above but with an additional L-band capability, designing and testing a dc and logic multilayer manifold for use with these modules, integrating all the hardware developed under NAS9-14196 and this contract (NAS9-14485) into an S-band phased array antenna subsystem, and testing this subsystem.



SECTION II

ANTENNA ARRAY SUBSYSTEM REQUIREMENTS

The antenna array subsystem requirements are based upon the set of system parameters outlined in Table 2-1. These requirements are closely keyed to using the existing technology developed under NASA Contract NAS8-25847 with MSFC. The system parameters have been updated several times during the course of this contract to reflect current JSC design requirements.

The system configuration envisions placement of at least four antenna arrays approximately 10.68 inches in diameter mounted on the spacecraft as shown in Figure 2-1.

A basic system block diagram is shown in Figure 2-2. To minimize the interface and most easily compliment the radio systems and onboard computer, the RF and computer signals and dc power will feed this system from a central point. (A configuration alternative might use multiple-point interface for redundancy at the expense of weight, power, and cost.) The radio system interface consists of a nominal transmitter input of +29 dBm at S-band and a receive output which feeds a transponder with a noise figure less than 8 dB. As noted in Table 2-1, the receive system also operates at L-band, but with degraded noise figure and gain.



Table 2-1. System Design Parameters

Transmit frequencies	2217.5 and 2287.5 MHz
Transmit EIRP (on boresight)	24 dBw
Transmit EIRP (scan angles) ¹	18 dBw
Array transmit power input	30 dBm maximum; 28 dBm minimum
Receiver frequencies: S-band ²	2041.9 and 2106.4 MHz
L-band	1775.5 and 1831.8 MHz
Receive noise temperature ³	600°K (design goal) and 700°K (maximum)
Receive antenna gain (on boresight)	11.5 dB
Receive antenna gain (60-degree scan)	5.5 dB
Antenna beamwidth (on boresight)	40° (nominal)
Array receive electronic gain S-band	20 dB
Array diameter	10.68 inches (main body)
Coverage	Maximized for four arrays on a 200-inch cylinder
Array thickness (including array steering controller but not power supply)	6 inches
Weight (four-array system less cables)	50 pounds (four arrays)
DC power (one array including controller)	130 watts
Steering angle commands (two)	8 bits each (maximum)
Phase variation	±12°
Amplitude variation	±0.7 dB
Phasing time	0.2 μs
Normal TPS bondline temperature near faceplate in front of antenna	-185° to +350°F
Surface curvature	Flat antenna aperture

¹ 70- by 50-degree elliptical scan with 70-degree scan along X-axis.

² With ±11-MHz spread spectrum at each S-band receive frequency.

³ Degraded performance acceptable at L-band receive frequencies.

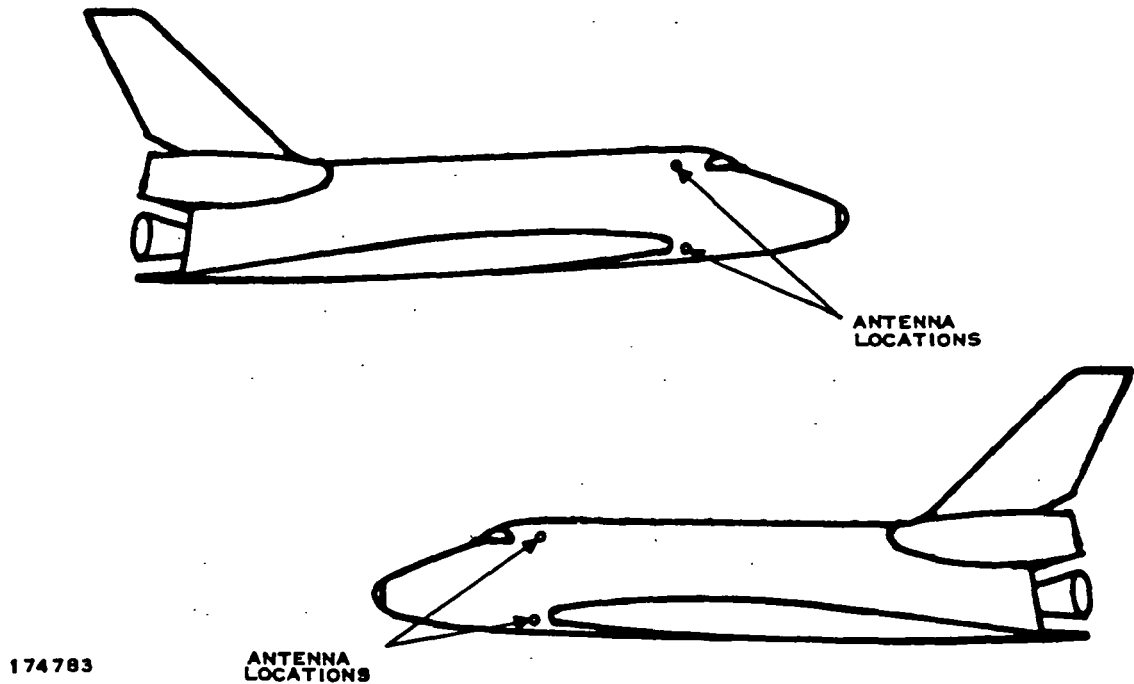


Figure 2-1. Antenna Locations

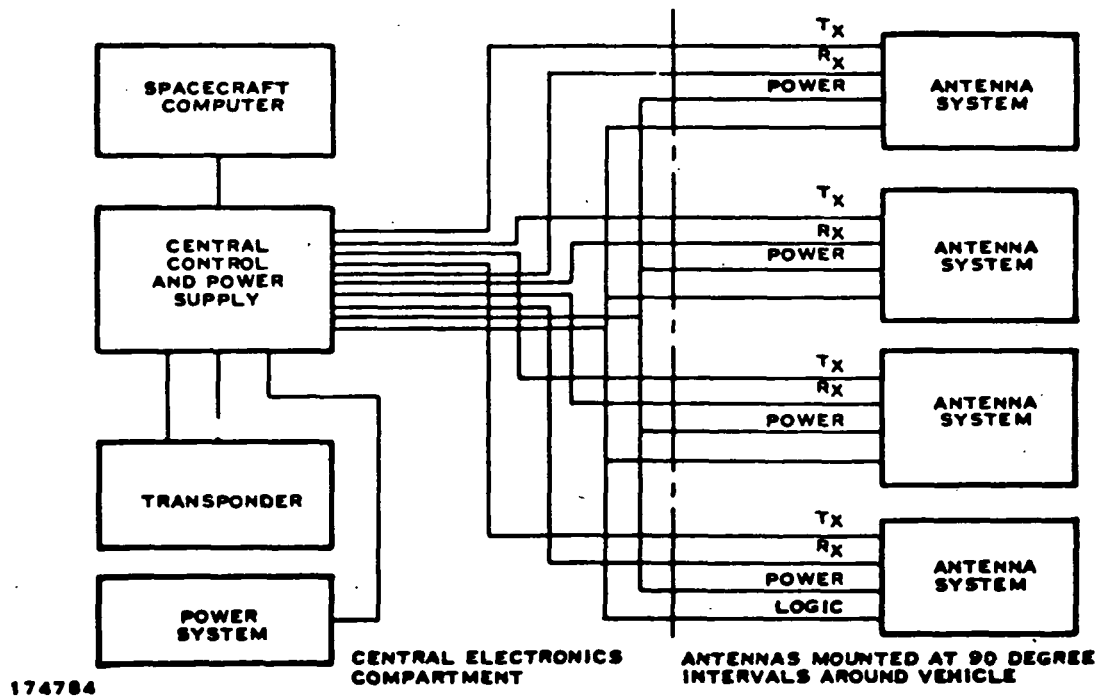


Figure 2-2. System Concept, Central Control



SECTION III

T/R MODULE DESIGN AND EVALUATION

A. OUTER MODULE (P/N SK 784010-1) EVALUATION

The five additional T/R modules for the outer rows of antenna elements were the same design and construction as the module developed under NASA Contract NAS9-14196 for JSC. Figures 3-1, 3-2, and 3-3 are photographs of this module, which is composed of 3-bit switched line transmitter and receiver phase shifters, a three-stage transmitter power amplifier, a transmitter ferrite isolator, an MIC transmitter edge-coupled filter, a three-port ferrite circulator duplexer, a receiver combline filter, and a receiver three-stage low-noise amplifier.

The specifications and test procedures for the T/R modules developed under this contract are given in Texas Instruments drawing number SKDD 301 (Appendix A of this report). The individual outer module test data for the five outer modules (MSN 003, 004, 005, 006, and 007) built under this contract are given in drawing number SKDD 302 (Appendix B). Also included is the SPACS I outer module (MSN 001 built under NASA Contract NAS9-14196) test data.

The transmitter side of all six modules built under this contract went together well and the test data was very close to the data obtained from the original breadboard module built under NAS9-14196. The transmitter test data for all seven modules used for this array subsystem is summarized in Table 3-1. As seen in this table, all the modules either met or were close to the contract design goals. The module transmitter input VSWR averaged 1.5:1, transmitter power output averaged +35 dBm, and transmitter gain averaged 22 dB. The module-to-module phase standard deviation averaged between 16 and 21 degrees. The design goal for this phase variation was less than one-half the smallest bit (which is 45 degrees).

The receiver side of all six modules built under this contract did not work as well as the original breadboard module built under NAS9-14196. The basic problem in the receiver area was the Avantek AT-4641 transistor shipment. The microwave parameters of the devices received on this contract were different from the microwave parameters of the devices received under NAS9-14196. The microwave parameters involved were the transistor S-parameter windows and the required source impedance for best noise performance. These differences caused the gain, gain flatness, and noise figure of the receiver side of the modules to be worse than the original breadboard module (MSN 001). The only way to improve performance on the present contract was to reorder all transistors, redesign the low-noise amplifier circuit, and reoptimize the receiver interfaces. Because this improvement would have required increased time and money and because timely execution of the contract was critical to supply antenna array data to NASA, module receiver performance was somewhat degraded in order to meet the schedule.

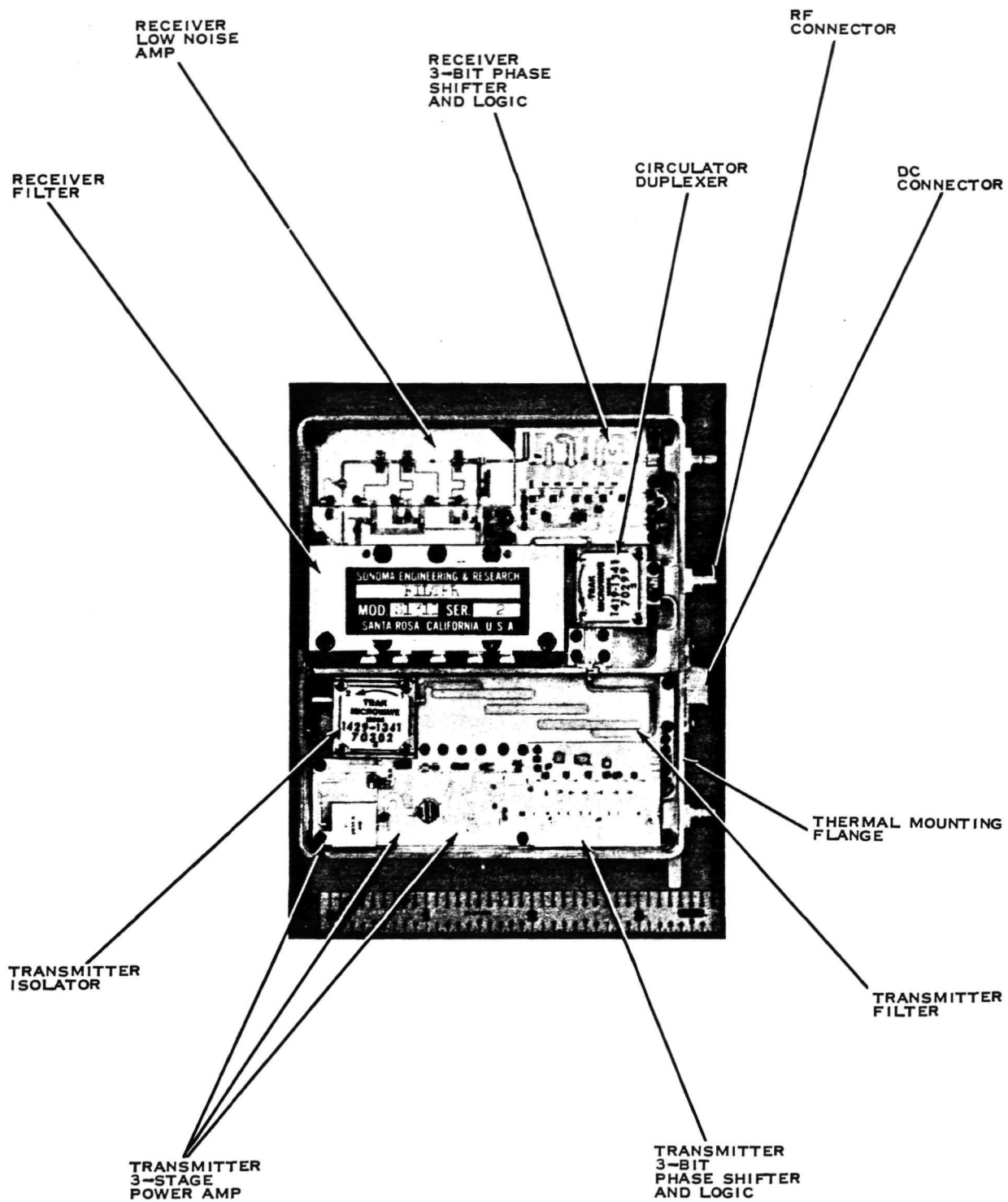


Figure 3-1. SPACS II Outer Module Layout Configuration

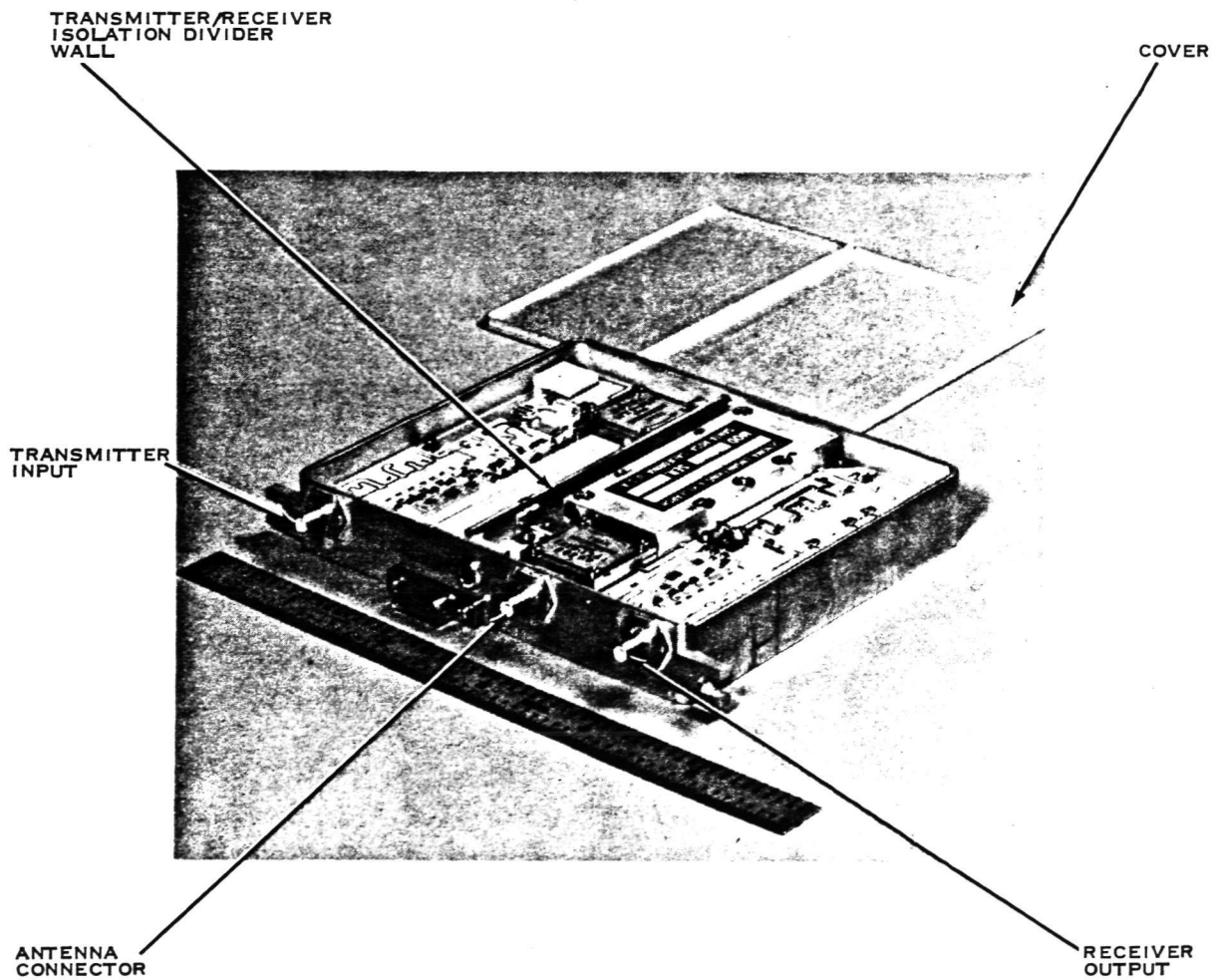


Figure 3-2. SPACS II Outer Module and Cover

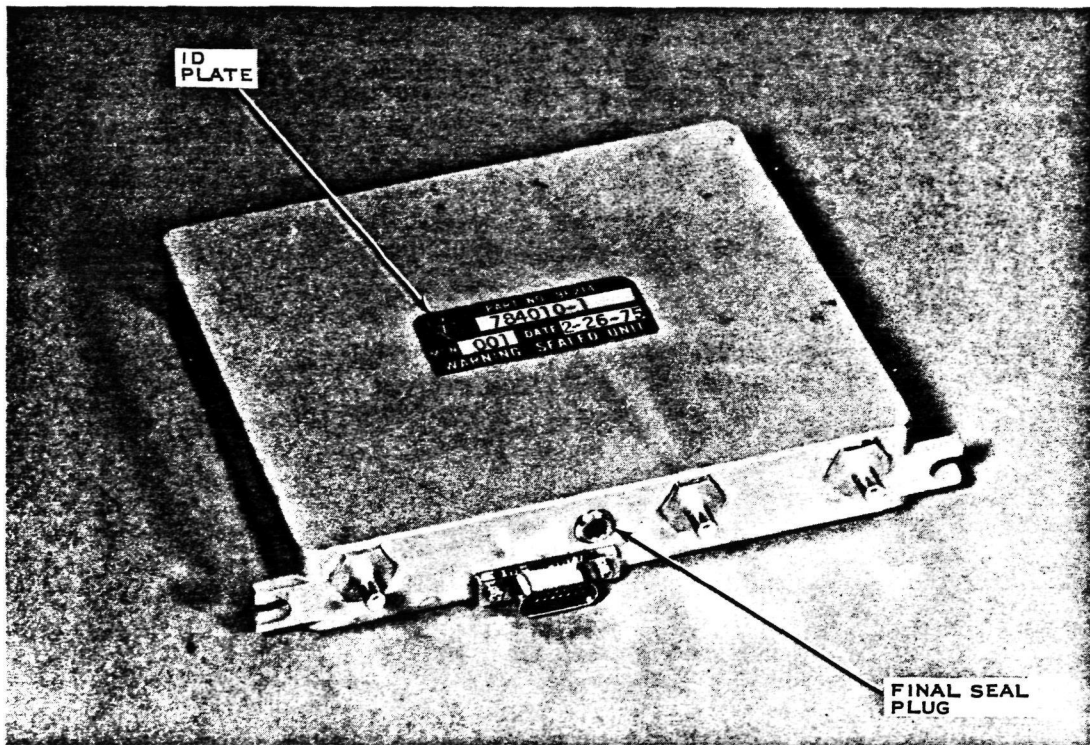


Figure 3-3. SPACS II Final Sealed Outer Module



Table 3-1. Summary of SPACS II Engineering Module Transmitter Test Data
(All data given for a module input power level of +13 dBm and at 0-degree reference phase length.)

Outer Module Serial Number P/N SK784010-1	2217.5 MHz			2287.5 MHz				
	Input VSWR	Output Power (dBm)	Gain (dB)	Phase Length (Degrees)	Input VSWR	Output Power (dBm)	Gain (dB)	Phase Length (Degrees)
MSN 001 (BB Unit)	1.43	34.8	21.4	84.0	1.87	35.7	22.7	78.2
MSN 003 (EM Unit)	1.34	35.6	22.6	72.6	2.19	35.0	22.0	125.9
MSN 004 (EM Unit)	1.17	35.3	22.3	62.5	2.12	34.2	21.2	93.5
MSN 005 (EM Unit)	1.46	35.2	22.2	65.3	1.35	34.0	21.1	108.8
MSN 006 (EM Unit)	1.82	35.0	22.0	82.2	1.55	35.7	22.7	65.5
MSN 007 (EM Unit)	1.50	35.7	22.7	51.5	1.07	35.6	22.6	82.6
Inner Module P/N SK446962-1	X	X	X	X	X	X	X	X
MSN 002 (EM Unit)	1.38	35.2	22.2	37.9	1.16	35.0	22.0	105.9
Mean Values, \bar{X} , All Modules	1.44	35.3	22.3	65.1	1.6	35.0	22.0	94.3
Standard Devi- ation, S, All Modules	0.2	0.3	0.3	16.5	0.5	0.7	0.7	20.7



To ensure that this problem does not reoccur in any future work, stricter specifications will be placed on the transistor S-parameter windows and source impedance for best noise figure. However, these stricter specifications will double the price of the AT-4641 transistors. Also, for any future module work, a variable thin-film attenuator will be placed in the output of the low-noise amplifier to allow adjustment of the module receiver gain. This should ensure that the receiver side of the module will have 30 dB of gain with ± 1 -dB maximum variation from module to module.

The receiver test data for the seven modules used for this array subsystem is summarized in Table 3-2, which shows that all the modules either met or were close to the contract design goals. The module receiver input VSWR averaged 2.1:1, receiver noise figure averaged between 5.3 and 6.0 dB, and receiver gain averaged 31.6 dB. Phase variations were between 20 to 30 degrees. The noise figure exceeded the design goal of 5.0 dB because of the transistor problem previously mentioned. The module-to-module phase variation also exceeded the goal of 22.5 degrees, and the module-to-module gain variation was greater than the design goal of ± 1 dB. Again, this was due to the transistor problem previously discussed.

As shown by the data sheets in Appendix B, the module receivers have low intermodulation products and 1-dB compression points between +1 and +10 dBm, and work under fully duplexed operation with the transmitter and receiver used at the same time. With the exception of the low-noise transistor problem, the outer modules performed as expected and met the majority of design goals.

B. INNER MODULE (P/N SK 446962-1) DESIGN AND EVALUATION

One center module was built using existing circuits from the previously discussed outer modules. The center module did not have a requirement for phase shifters in either the transmitter or receiver sections. In place of the 3-bit phase shifters, simple phase adjust networks were used in the transmitter and receiver. The center module had the additional capability of receiving L-band signals at 1775.5 MHz and 1831.8 MHz, and outputting these signals through a separate RF connector.

Figures 3-4 and 3-5 are photographs of the completed center module. This center module is similar to the outer modules but is 1 inch longer because of the extra circuitry required.

The transmit phase adjust network shown in the figures consists of four spurline phase adjustment (analog) sections, with each capable of being adjusted from 10 to 100 degrees in 5-degree increments. This adjustment takes place by moving welded gold ribbons up or down the spurlines as required. The transmit phase adjustment network is designed to provide ± 180 electrical degrees of adjustment to ensure its phase length is close to that of the other six outer modules. A 2-dB thin-film pad is mounted on the phase adjust network. Since this circuit has no diodes to create as much loss as the



Table 3-2. Summary of SPACS II Engineering Module Receiver Test Data
(All data given for a module input power level
of -40 dBm and at 0-degree reference phase length.)

Outer Module Serial Number P/N SK784010-1	2041.9 MHz				2106.4 MHz			
	Int VSWR	Noise Figure (dB)	Gain (dB)	Phase Length (Degrees)	Input VSWR	Noise Figure (dB)	Gain (dB)	Phase Length (Degrees)
MSN 001 (BB Unit)	2.03	4.6	34.5	-118.9	2.32	4.1	34.5	-57.4
MSN 003 (EM Unit)	1.26	6.1	33.1	-149.1	1.34	5.3	32.1	-113.3
MSN 004 (EM Unit)	2.85	6.2	30.7	-108.9	2.04	5.1	30.0	-62.1
MSN 005 (EM Unit)	1.30	6.1	32.0	-162.1	1.78	5.8	31.5	-134.0
MSN 006 (EM Unit)	1.32	5.7	33.1	-133.6	1.29	4.9	33.9	-88.7
MSN 007 (EM Unit)	1.58	6.9	30.5	-154.7	1.70	5.6	30.4	-109.6
<hr/>								
Inner Module P/N SK446962-1	X	X	X	X	X	X	X	X
MSN 002 (EM Unit)	3.2	6.3	27.3	-151.5	8.6	6.0	29.2	-121.4
<hr/>								
Mean Values, \bar{X} , All Modules	1.93	6.0	31.6	-139.8	2.72	5.3	31.7	-98.1
Standard Devi- ation, S, All Modules	0.8	0.7	2.37	19.9	2.62	0.6	2.0	29.5

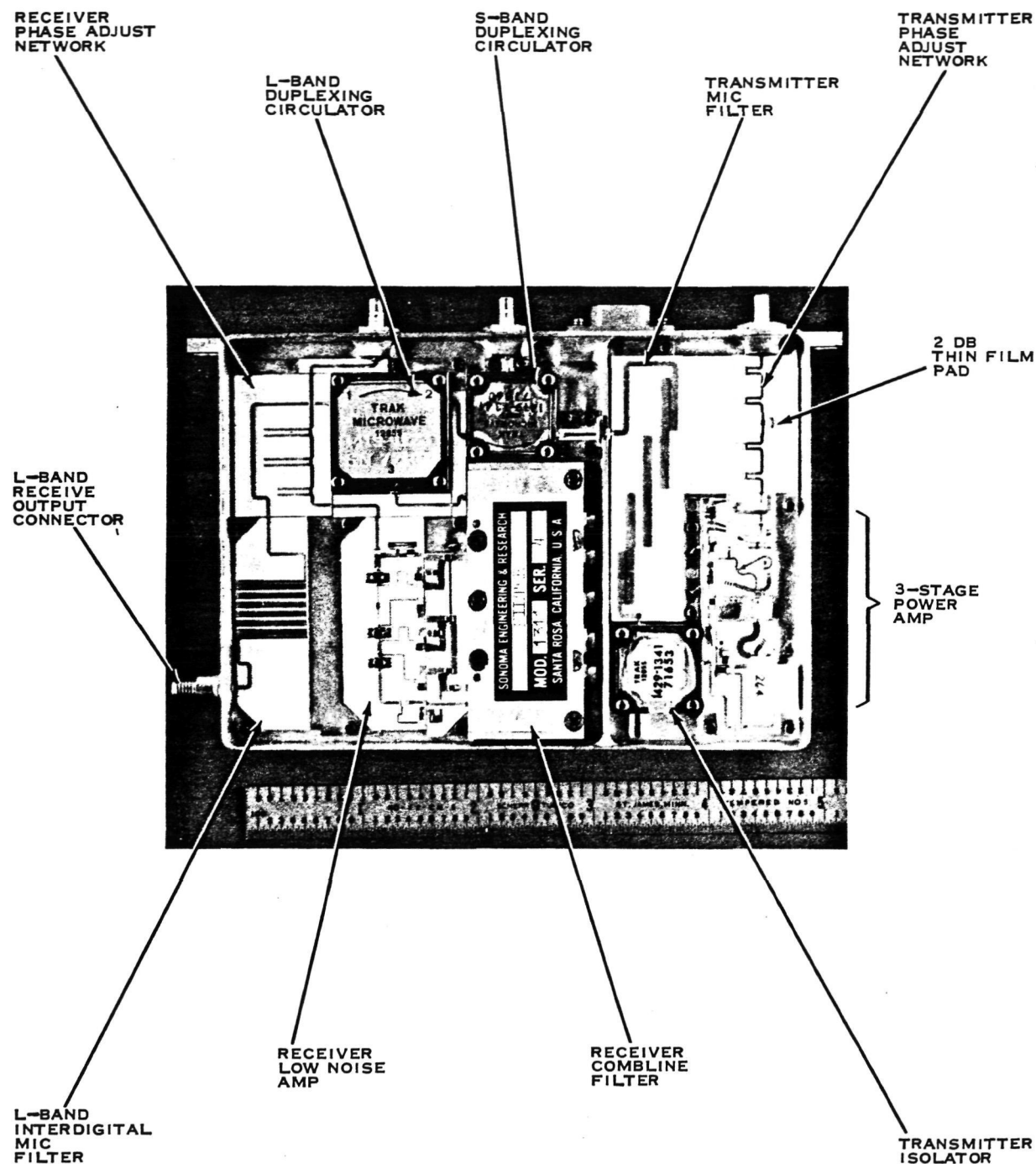


Figure 3-4. SPACS II Center Module Layout Configuration, Top View

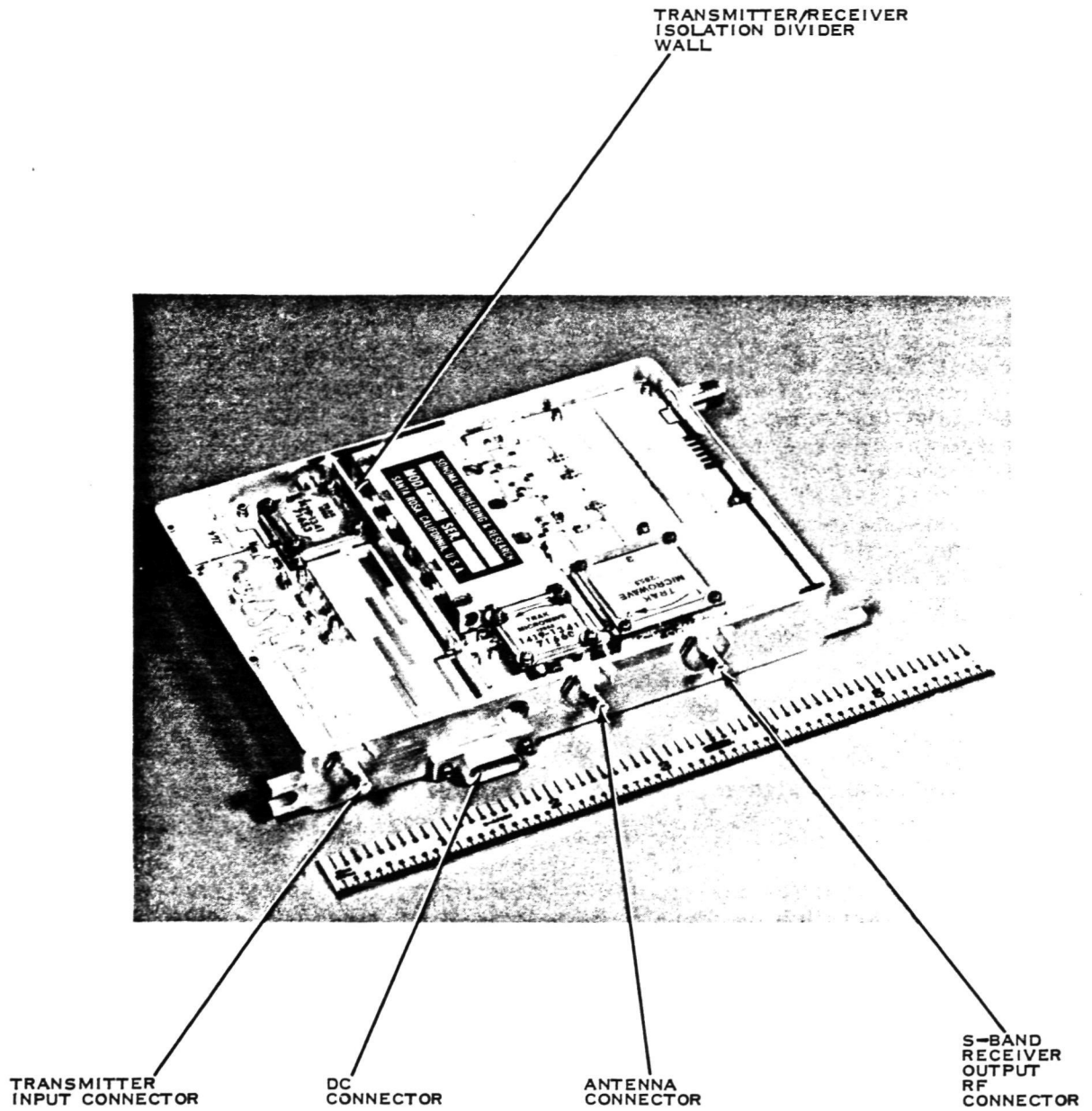


Figure 3-5. SPACS II Center Module, Oblique View



original phase shifter circuit, this attenuator is required to ensure that the input drive power to the three-stage power amplifier remains the same as the other six modules. Most of the module circuits, including the phase adjust circuit, are built using MIC construction on Al_2O_3 ceramic substrates. ANA data taken on a transmit phase adjust network is shown in Table 3-3.

The receiver phase adjust network (Figures 3-4 and 3-5) consists of three spurline phase adjustment (analog) sections, with one capable of being adjusted from 10 to 110 degrees in 5-degree increments, and the other two sections capable of being adjusted from 10 to 140 degrees in 5-degree increments. This adjustment takes place by moving welded gold ribbons up or down the spurlines as required. The receiver phase adjust network is designed to provide ± 180 electrical degrees of adjustment to ensure its phase length is close to that of the other six outer modules. A 50-ohm transmission line is also included on the receiver phase adjust circuit. This line routes the L-band receive signal from the L-band circulator to the L-band filter. The receive phase adjust network also uses microstrip construction techniques.

The thin-film pad used on the transmit phase adjust network is not included as part of the receiver phase adjust network. This is because there is approximately 1 dB of extra loss already in the receiver section due to the extra L-band circulator and 50-ohm routing lines. This already puts the gain of the center module receiver section close to that of the outer modules. ANA data was taken on the receive phase adjust network. Its loss was approximately 0.8 dB with a 1.2:1 VSWR.

The L-band circulator shown in Figure 3-4 properly routes the S-band and L-band receive signals. On receive, a signal enters the S-band duplexing circulator and is routed to the L-band circulator. The L-band circulator then routes the receive signal to the receiver combline filter.

If the receive signal is an S-band signal (2041.9 MHz or 2106.4 MHz), it passes through the receiver combline filter, is amplified, and passes out through the S-band receiver output RF connector. If the receive signal is an L-band signal (1775.5 MHz or 1831.8 MHz), it is reflected from the combline filter back to the L-band circulator. From the L-band circulator, the L-band receive signal is routed over the receive phase adjust network to the L-band MIC filter and through the L-band filter to the L-band output RF connector. The ANA test data taken on the L-band circulator is shown in Tables 3-4 and 3-5.

The L-band MIC filter shown in Figure 3-4 is an interdigitated type adapted from the AESPA contract NAS8-25847 with MSFC. This filter is a six-section ($n = 6$ resonators) Chebyshev bandpass design using microstrip construction on 0.025-inch-thick alumina ceramic. The length of the resonators is approximately a quarter wavelength at a center frequency of 1800 MHz. In an interdigitated design, each resonator is grounded at one end and open at the other end. This pattern is staggered across the filter as shown by Figure 3-6. This filter must have approximately 2-dB insertion loss at L-band receive frequencies and must reject S-band receive and transmit signals by at least 30 dB.



Table 3-3. Transmit Phase Adjust Circuit,
Automatic Network Analyzer Test Data

Conn device - Transmit phase adjust S/N 1; P/N SK446987; 5/12/75; DRD

<u>FREQUENCY</u>	<u>REFL</u>	<u>ANGLE</u>	<u>RTN LS</u>	<u>VSWR</u>	<u>GAIN</u>	<u>PHASE</u>	<u>DELAY</u>
2100.000	0.149	-105.9	16.5	1.351	-2.28	-160.6	0.702
2120.000	0.148	-107.4	16.6	1.348	-2.35	-165.7	0.728
2140.000	0.148	-108.3	16.6	1.346	-2.41	-170.9	0.686
2160.000	0.144	-108.5	16.8	1.338	-2.45	-175.9	0.685
2180.000	0.143	-109.0	16.9	1.334	-2.50	179.2	0.791
2200.000	0.151	-109.5	16.4	1.357	-2.60	173.5	0.728
2220.000	0.151	-110.9	16.4	1.354	-2.66	168.3	0.626
2240.000	0.139	-108.8	17.2	1.322	-2.61	163.7	0.656
2260.000	0.131	-111.2	17.7	1.301	-2.67	159.0	0.701
2280.000	0.128	-113.2	17.9	1.293	-2.70	154.0	0.725
2300.000	0.126	-115.6	18.0	1.287	-2.75	148.8	0.726
2320.000	0.124	-118.4	18.2	1.282	-2.75	143.5	0.718
2340.000	0.124	-121.8	18.2	1.282	-2.79	138.4	0.752
2360.000	0.126	-125.8	18.0	1.288	-2.83	132.9	0.722
2380.000	0.128	-130.1	17.9	1.293	-2.90	127.7	0.734
2399.999	0.131	-134.5	17.7	1.300	-2.92	122.5	0.734



Table 3-4. L-Band Circulator (P/N 1419-1123),
Automatic Network Analyzer Test Data for Through Path

Conn device - TRAK L-band circulator; P/N 1419-1123; S/N 72105, port 2 to
port 3 6/6/75; DRD

<u>FREQUENCY</u>	<u>REFL</u>	<u>ANGLE</u>	<u>RTN LS</u>	<u>VSWR</u>	<u>GAIN</u>	<u>PHASE</u>	<u>DELAY</u>
1500.000	0.443	123.2	7.1	2.589	-2.06	-94.5	1.048
1525.000	0.396	116.9	8.0	2.311	-1.65	-104.0	1.198
1550.000	0.351	110.3	9.1	2.083	-1.64	-114.8	1.401
1575.000	0.309	102.4	10.2	1.894	-1.55	-127.4	1.272
1600.000	0.284	94.1	10.9	1.793	-1.19	-138.8	1.078
1625.000	0.267	87.9	11.5	1.729	-0.99	-148.5	1.212
1650.000	0.241	82.5	12.4	1.634	-1.05	-159.4	1.378
1675.000	0.210	73.8	13.6	1.531	-0.97	-171.8	1.206
1700.000	0.196	64.2	14.2	1.488	-0.80	177.3	1.241
1725.000	0.180	56.2	14.9	1.438	-0.78	166.1	1.257
1750.000	0.158	48.1	16.0	1.376	-0.62	154.8	1.052
1775.000	0.133	36.5	17.5	1.306	-0.46	145.4	1.043
1800.000	0.114	21.3	18.8	1.258	-0.59	136.0	1.278
1825.000	0.099	6.1	20.1	1.220	-0.81	124.5	1.336
1850.000	0.084	-10.5	21.5	1.183	-0.68	112.4	1.080
1875.000	0.071	-30.0	22.9	1.153	-0.40	102.7	0.975
1900.000	0.062	-50.8	24.1	1.133	-0.51	94.0	1.268
1925.000	0.057	-75.0	24.9	1.121	-0.75	82.5	1.298
1950.000	0.058	-101.1	24.7	1.124	-0.69	70.9	1.069
1975.000	0.066	-120.6	23.6	1.142	-0.50	61.2	0.944
2000.000	0.072	-136.6	22.8	1.156	-0.55	52.7	1.110
2025.000	0.079	-151.9	22.0	1.172	-0.80	42.7	1.285
2050.000	0.088	-164.4	21.1	1.194	-0.85	31.2	1.087
2075.000	0.098	-174.6	20.2	1.217	-0.71	21.4	0.996
2100.000	0.105	176.2	19.6	1.234	-0.75	12.4	1.118
2125.000	0.112	166.6	19.0	1.251	-0.87	2.4	1.079
2150.000	0.120	156.0	18.4	1.272	-0.89	-7.3	1.040
2175.000	0.126	145.8	18.0	1.289	-0.99	-16.7	1.103
2199.999	0.130	134.5	17.7	1.300	-1.17	-26.6	1.103



Table 3-5. L-Band Circulator (P/N 1419-1123),
Automatic Network Analyzer Test Data for Isolated Path
Port 3 to Port 2

<u>FREQUENCY</u>	<u>REFL</u>	<u>ANGLE</u>	<u>RTN LS</u>	<u>VSWR</u>	<u>GAIN</u>	<u>PHASE</u>	<u>DELAY</u>
1500.000	0.388	-166.7	8.2	2.267	-10.40	166.6	1.575
1525.000	0.334	-173.3	9.5	2.002	-10.55	152.5	1.408
1550.000	0.286	-178.9	10.9	1.800	-10.96	139.8	1.514
1575.000	0.244	176.4	12.3	1.644	-11.79	126.2	1.796
1600.000	0.208	172.6	13.6	1.526	-12.48	110.0	1.564
1625.000	0.175	169.5	15.1	1.424	-12.93	95.9	1.343
1650.000	0.150	166.6	16.5	1.352	-13.87	83.8	1.537
1675.000	0.125	164.8	18.0	1.287	-15.10	70.0	1.572
1700.000	0.104	163.0	19.6	1.233	-16.10	55.9	1.401
1725.000	0.083	161.8	21.6	1.182	-17.16	43.3	1.135
1750.000	0.065	162.6	23.8	1.138	-18.48	33.0	1.243
1775.000	0.046	169.6	26.8	1.096	-20.14	21.9	1.221
1800.000	0.032	-170.9	30.0	1.066	-21.92	10.9	0.982
1825.000	0.030	-137.4	30.5	1.062	-23.91	2.0	0.630
1850.000	0.041	-113.7	27.7	1.086	-26.01	-3.7	0.239
1875.000	0.058	-105.7	24.7	1.124	-28.42	-5.8	0.519
1900.000	0.077	-104.2	22.3	1.167	-30.49	-1.1	1.191
1925.000	0.091	-107.9	20.9	1.199	-31.64	9.6	0.860
1950.000	0.109	-113.9	19.3	1.243	-31.54	17.3	0.326
1975.000	0.128	-119.6	17.8	1.295	-30.45	20.3	0.149
2000.000	0.143	-123.4	16.9	1.333	-29.77	18.9	0.681
2025.000	0.152	-129.5	16.4	1.359	-28.88	12.8	1.025
2050.000	0.163	-136.9	15.7	1.391	-28.51	3.6	1.232
2075.000	0.176	-144.0	15.1	1.428	-28.46	-7.5	1.009
2100.000	0.189	-150.2	14.5	1.466	-28.82	-16.6	1.140
2125.000	0.196	-156.4	14.2	1.486	-29.61	-26.8	0.717
2150.000	0.202	-164.8	13.9	1.507	-31.41	-33.3	0.147
2175.000	0.212	-174.0	13.5	1.537	-34.18	-32.0	2.566
2199.999	0.216	176.7	13.3	1.552	-36.20	-8.9	2.566

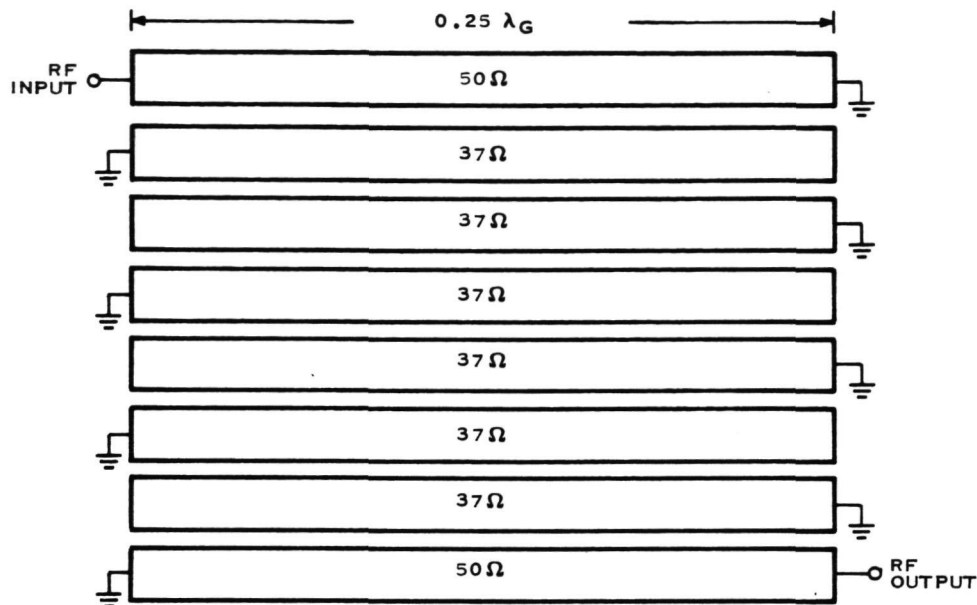


Figure 3-6. L-Band MIC Interdigitated Filter Topology

ANA test data on this L-band filter is shown in Table 3-6. This data shows that the filter had less than 2-dB loss at 1775.5 and 1831.8 MHz. Also, it averaged over 40 dB of rejection across the S-band transmit and receive frequencies.

The specifications and test procedures for the inner T/R module are also given by Texas Instruments drawing number SKDD 301 (Appendix A). The individual module test data for the center module (MSN 002) built under this contract is given as drawing number SKDD 302 (Appendix C). A summary of the S-band transmitter and receiver data was included in Tables 3-1 and 3-2 for comparison with the other modules built under this contract. The module L-band receive loss was 3.75 dB at 1775.5 MHz and 3.39 dB at 1831.8 MHz, which meets the module design goal of less than 4 dB.

As with outer modules, the transmitter side of the center module went together well and met all of the design parameters. The receiver side of the center module had the same problems with respect to gain uniformity, gain flatness, and noise figure as previously discussed for the outer modules.



Table 3-6. L-Band MIC Interdigitated Filter,
Automatic Network Analyzer Test Data

Conn device; L-band filter; P/N SK446972-1; S/N 5; 5/13/75; DRD

<u>FREQUENCY</u>	<u>REFL</u>	<u>ANGLE</u>	<u>RTN LS</u>	<u>VSWR</u>	<u>GAIN</u>	<u>PHASE</u>	<u>DELAY</u>
1500.000	0.934	129.2	0.6	29.109	-16.11	-129.5	2.405
1525.000	0.874	110.7	1.2	14.835	-11.03	-151.1	4.355
1550.000	0.615	79.8	4.2	4.198	-4.99	169.7	7.323
1575.000	0.228	141.1	12.8	1.592	-2.16	103.8	5.273
1600.000	0.573	126.5	4.8	3.687	-3.51	56.3	3.565
1625.000	0.614	100.1	4.2	4.182	-3.89	24.2	3.542
1650.000	0.502	73.2	6.0	3.020	-2.92	-7.7	4.230
1675.000	0.245	48.3	12.2	1.650	-1.79	-45.7	4.699
1700.000	0.127	129.0	17.9	1.292	-1.59	-88.0	4.329
1725.000	0.312	120.8	10.1	1.905	-1.94	-127.0	4.014
1750.000	0.347	96.1	9.2	2.061	-2.07	-163.1	4.189
1775.000	0.250	75.9	12.1	1.666	-1.89	159.2	4.616+
1800.000	0.136	96.5	17.3	1.314	-1.66	117.7	4.616
1825.000	0.214	117.0	13.4	1.543	-1.82	76.1	4.538+
1850.000	0.245	94.5	12.2	1.648	-2.04	35.3	4.830
1875.000	0.131	68.4	17.6	1.303	-1.89	-8.2	5.223
1900.000	0.098	168.8	20.2	1.216	-2.04	-55.2	5.639
1925.000	0.221	141.6	13.1	1.566	-2.52	-106.0	6.531
1950.000	0.112	137.2	19.0	1.253	-2.75	-164.7	8.382
1975.000	0.325	174.4	9.8	1.962	-4.23	119.8	12.723
2000.000	0.494	-175.5	6.1	2.950	-9.73	5.3	6.621
2025.000	0.825	141.2	1.7	10.445	-31.57	-54.3	10.032+
2050.000	0.872	117.7	1.2	14.636	-42.87	36.0	0.241
2075.000	0.893	101.6	1.0	17.737	-42.04	38.2	0.906
2100.000	0.911	88.3	0.8	21.360	-43.54	30.0	1.311
2125.000	0.918	76.7	0.7	23.424	-45.55	18.2	0.920
2150.000	0.922	66.1	0.7	24.525	-47.68	10.0	1.208
2175.000	0.923	56.3	0.7	25.085	-49.85	-0.9	0.604
2200.000	0.920	46.9	0.7	23.884	-52.11	-6.3	0.723
2225.000	0.921	37.9	0.7	24.398	-53.70	-12.9	0.200
2250.000	0.921	29.0	0.7	24.397	-55.32	-14.7	0.036
2275.000	0.922	20.4	0.7	24.712	-56.37	-15.0	0.350
2300.000	0.927	11.8	0.7	26.377	-57.45	-18.1	0.419
2325.000	0.935	3.2	0.6	29.782	-58.18	-21.9	0.036
2350.000	0.939	-5.3	0.6	31.581	-59.97	-22.2	0.122
2375.000	0.943	-13.6	0.5	34.269	-60.45	-21.1	0.394
2400.000	0.951	-21.8	0.4	39.486	-59.69	-24.7	0.696
2425.000	0.948	-30.1	0.5	37.798	-59.97	-18.4	0.327
2450.000	0.946	-38.1	0.5	35.989	-58.97	-21.4	0.020
2475.000	0.950	-46.1	0.4	38.736	-59.78	-21.2	1.131
2499.999	0.949	-54.2	0.5	38.354	-59.73	-11.0	1.131



C. SUMMARY AND RECOMMENDATIONS

In summary, the modules went together well and met the majority of design parameters. There was no problem with the transmitter side of the modules, which had performance data very close to the original breadboard module (MSN 001).

The receiver section had a few problems originating in the AT-4641 transistor shipment. Overall, the receiver met the majority of design parameters and worked well enough to give good antenna array performance. The following list describes the areas in the receiver side that need improvement for the next module design.

1. Add a variable thin-film attenuator pad between the low-noise amplifier and the receiver phase shifter so that module receiver gain can be set at 30 ± 1 dB. This will ensure a more uniform module-to-module gain.
2. Place tighter specification windows on the low-noise amplifier AT-4641 transistors. This will ensure that the gain flatness and noise figures will be met for a given low-noise amplifier circuit design. The parameters to be more restrictive are the S parameters (especially S_{11} and S_{22}) and source impedance for optimum low-noise figure.
3. Add grounding posts at quarter-wave intervals in the module (especially on the receiver side) to prevent any spurious oscillations due to cavity-type moding.
4. Add a grounding clip between the combline filter and the module cover for better grounding on this unit, which will result in better transmitter rejection.
5. Improve the phase alignment test procedure for better module-to-module phase length uniformity. Overall, transmit and receive phase length variations should be reduced to less than ± 10 degrees.

With these improvements incorporated into future SPACS modules, better array performance can be assured. These improvements should reduce overall module production costs and simplify module testing.



SECTION IV

DC AND LOGIC MANIFOLD DEVELOPMENT

The second major item developed on this contract is a dc and logic multilayer board (MLB) manifold. All dc and logic signals enter the array through a 31-pin MS connector located on the array outer housing. The connector pin assignment is detailed in Texas Instruments drawing number SK446943. From this connector, all dc and logic signals are routed to the dc and logic manifold through a short wiring harness. The details of this wiring harness are covered by Texas Instruments drawing number SK446985. This wiring harness has two branches. All dc signals enter a 15-pin miniature connector located on the dc and logic manifold (pin assignments for this connector are detailed in Texas Instruments drawing number SK446979). All logic signals enter a 31-pin miniature connector located on the dc and logic manifold (pin assignments for this connector are detailed in Texas Instruments drawing number SK446980).

In future contracts, a small steering controller will be developed capable of taking five serial logic commands as inputs and converting them to the proper logic commands to input to each of the six T/R microelectronics modules. This steering controller module will eventually plug into the 31-pin logic connector on the dc and logic manifold.

The dc and logic manifold takes the major dc and logic input signals from the array input connector and properly routes them to each of the seven modules. In addition to the two connectors already described, the dc and logic manifold has seven additional 15-pin miniature connectors. The pin assignment for six of these connectors is detailed by Texas Instruments drawing number SK446982, and the seventh connector is covered by Texas Instruments drawing number SK446981.

Figures 4-1 and 4-2 show the dc and logic manifold designed, fabricated, and tested on this contract. As shown by these figures, three clearance holes for each module are drilled in the dc and logic manifold to provide access to the RF connectors that go to the transmit manifold, receive manifold, and antenna elements.

The dc and logic manifold, constructed of 12 conductor layers, is 10.4 inches in diameter and 0.095 inch thick. It contains six plastic insulating sheets with copper on both sides of the sheet. After etching each conductor layer with the proper artwork, the sheets are bonded together with glass cloth and epoxy adhesive. Holes that feed through to connect each of the proper layers are plated through using special techniques. Detailed dimensions and construction techniques are covered in Texas Instruments drawing number SK446976.

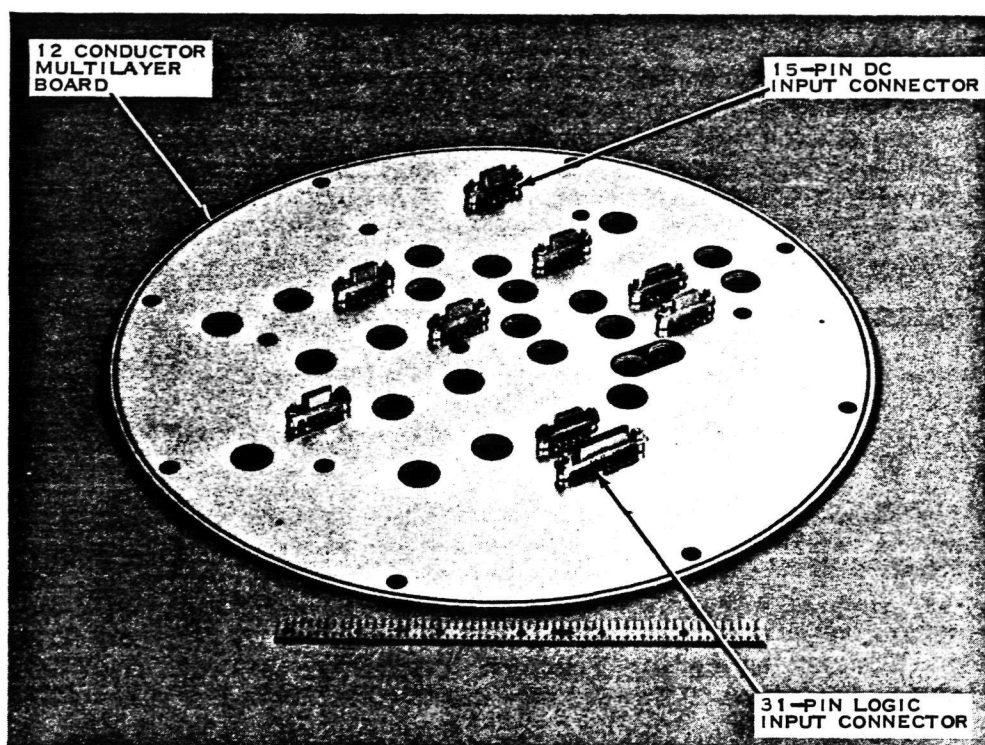


Figure 4-1. SPACS II DC and Logic Manifold
Assembled, Oblique View

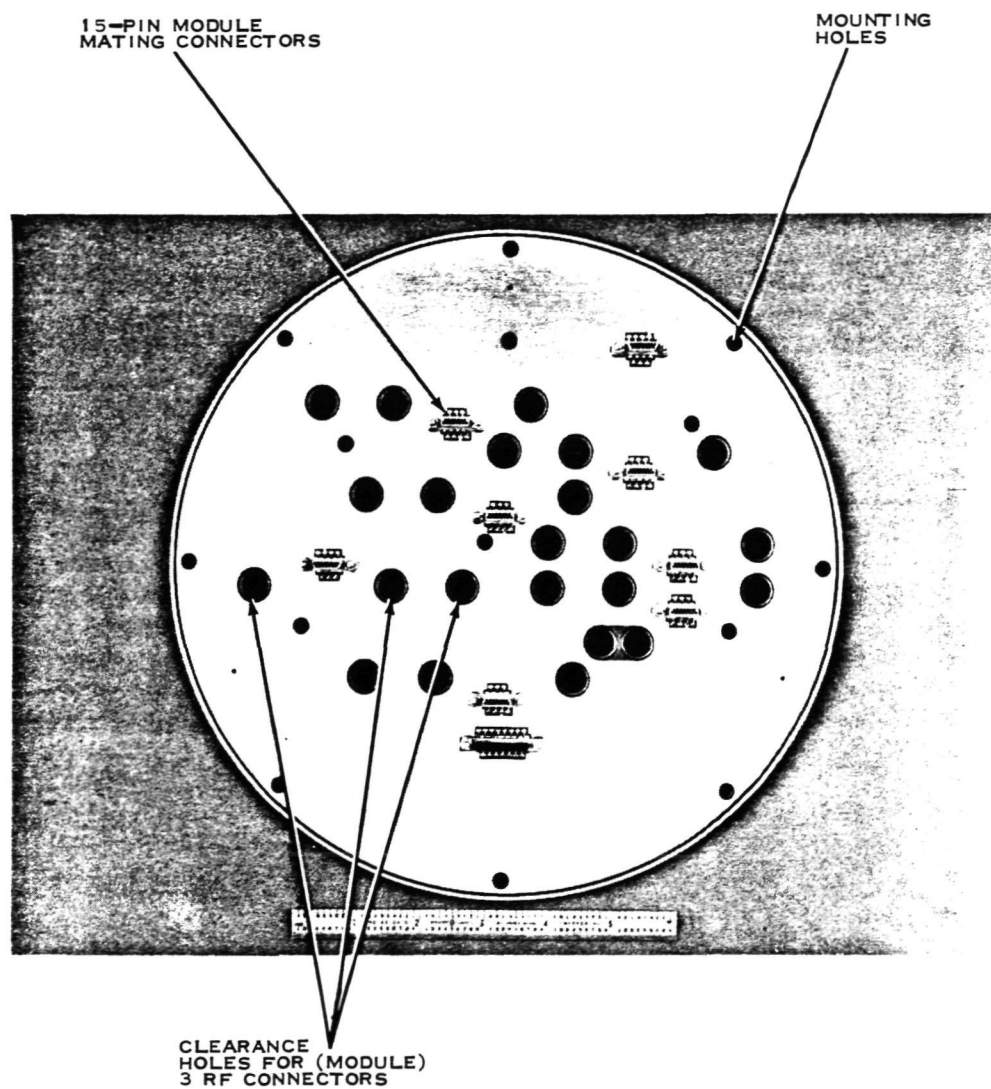


Figure 4-2. SPACS II DC and Logic Manifold, Top View



After routing and drilling the clearance holes, a special plating material is deposited on the outer ground planes. Following fabrication, the board is checked with an ohmmeter to ensure good electrical continuity. The interconnection diagram is covered in Texas Instruments drawing number SK446988.

After checkout, the manifold miniature connectors are installed and soldered into place. Following assembly, final electrical tests and mechanical inspections are performed in accordance with Texas Instruments drawing number SKDD 501 (Appendix D). These tests and inspections ensure overall compatibility with the array requirements.

The 12 individual conductor layers that make up the dc and logic manifold are listed in Table 4-1.

Table 4-1. DC and Logic Manifold Conductor Layer Assignment

Table of Layers			
No.	Description	Remarks	Copper Weight (ounces)
L1	Top layer and ground	Pads and plane	1
L2	Power, +22 Vdc	Plane	1
L3	Signal, transmitter clock	Conductor lines	1
L4	Power, +12 Vdc	Conductor lines	1
L5	Signal, receiver clock	Conductor lines	1
L6	Power, +5 Vdc	Plane	1
L7	Signal, 45° bit	Conductor lines	1
L8	Ground	Plane	1
L9	Signal, 90° bit	Conductor lines	1
L10	Signal, Enable	Plane	1
L11	Signal, 180° bit	Conductor lines	1
L12	Bottom layer and ground	Pads and plane	1

Some layers are purely conductor planes (solid conductors) and other layers have signal lines etched on them.

In summary, the dc and logic manifold was designed, built, and tested. It performed well electrically and was mechanically compatible with the rest of the array hardware, including the T/R microelectronics modules. All dc paths have sufficient safety margins to carry the required current levels. All logic signal paths provide sufficient isolation to prevent signal crosstalk between layers. The dc and logic manifold works perfectly.



SECTION V

ARRAY INTEGRATION AND SUBSYSTEM TESTS

A. ARRAY INTEGRATION

The third major task required by the contract was the integration and testing of all antenna subsystem hardware developed for Contract NAS9-14196 with the hardware developed for this contract. The hardware involved with this effort is listed below:

- Antenna elements and balun board
- Transmit RF manifold
- Receive RF manifold
- DC and logic manifold
- One BB T/R outer module
- Five EM T/R outer modules
- One EM T/R center module
- Array housing
- Short array wiring harness
- Three RF semirigid cables
- Finned heatsink and fan.

No problems were encountered during hardware integration; all hardware was compatible from both mechanical and electrical standpoints. The only minor difficulty encountered during testing was the array overheating. The array was tested on an outdoor antenna range with temperatures reaching 105°F. In addition, RF-absorbing insulation was placed around the back of the array to prevent reflections when using the standard gain horn reference unit. This material prevented any air flow around the array. The array will eventually have a liquid-cooled heatsink incorporated as an integral part of the unit. To prevent the breadboard array from overheating during testing, a finned heatsink and fan (+26 Vdc at 180 mA) was added to the back of the array. This reduced the array temperature from 60°C to 30°C.

Figures 5-1 through 5-5 show the integrated antenna subsystem configuration that was tested. Overall array dimensions, including the finned heatsink, are 10 inches in diameter (array body) by 7 inches deep. Final weight of the shipped array was 17 pounds.

B. ANTENNA ARRAY SUBSYSTEM TESTS

The SPACS II antenna array subsystem was tested on an outdoor antenna range at Texas Instruments, Dallas. The array was mounted in a large curved



ANTENNA ELEMENT
TERMINATING
MATERIAL

SQUARE SPIRAL
ANTENNA ELEMENT

ARRAY MOUNTING
RING

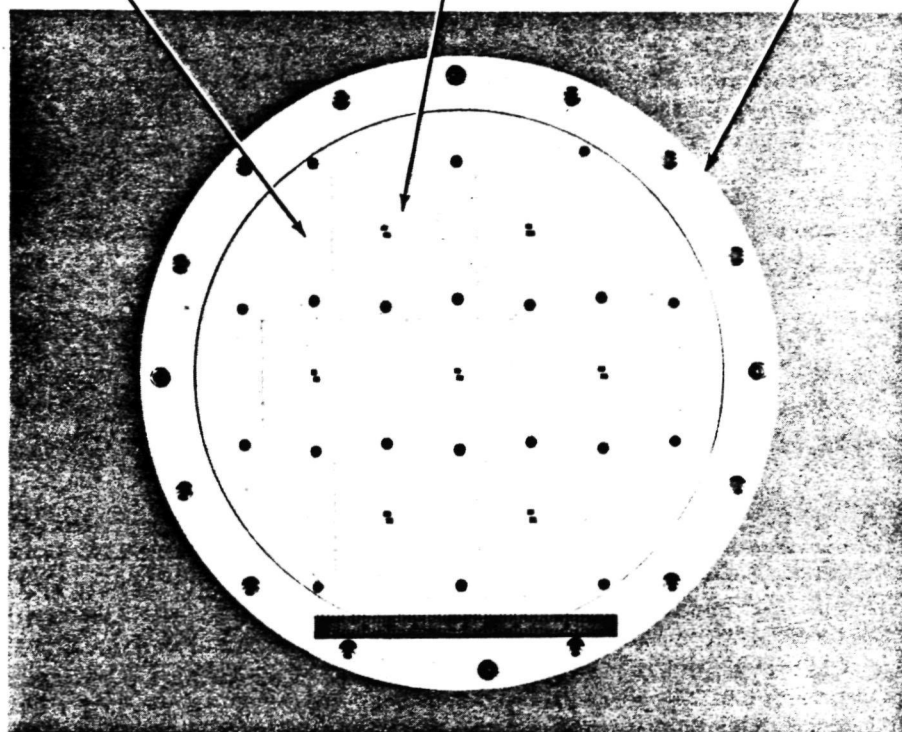


Figure 5-1. SPACS II Antenna Subsystem,
Antenna Element View

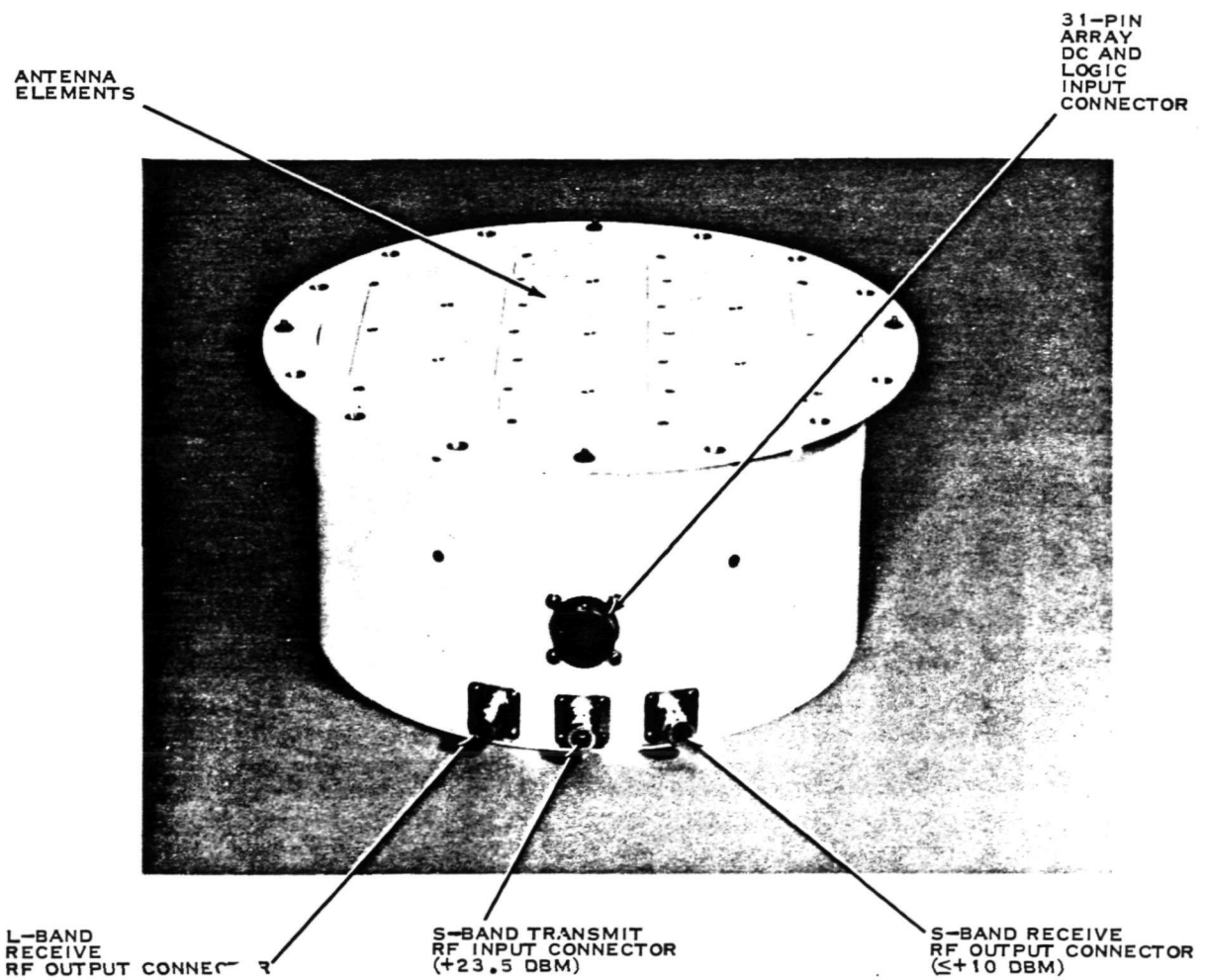


Figure 5-2. SPACS II Antenna Subsystem,
Side View with Connectors

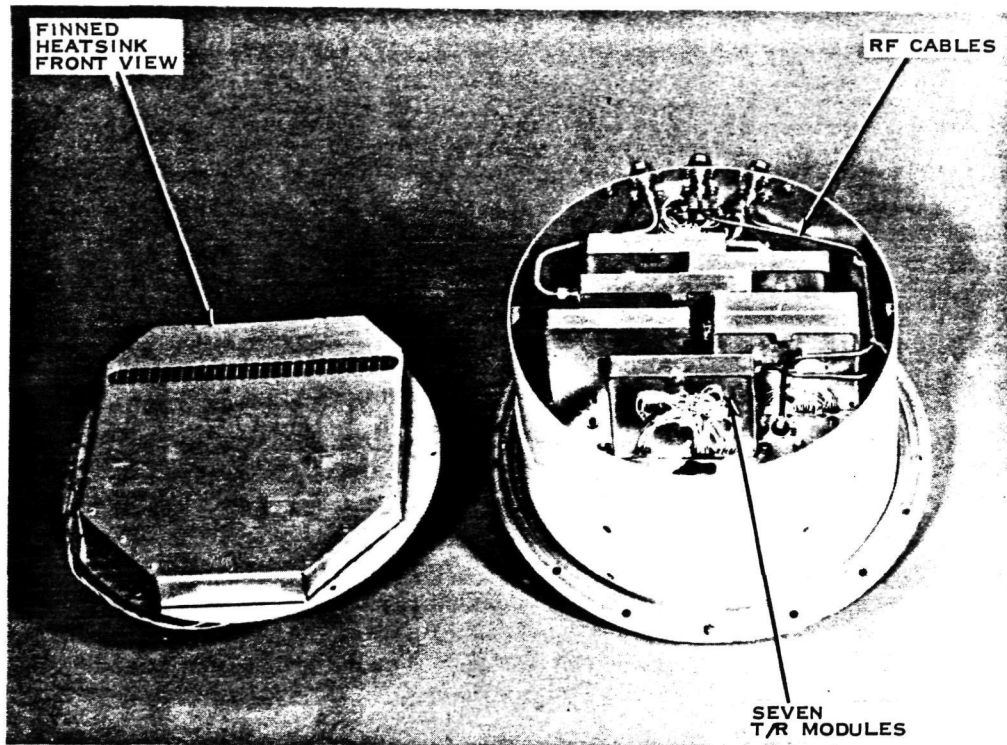


Figure 5-3. SPACS II Antenna Subsystem, Internal View

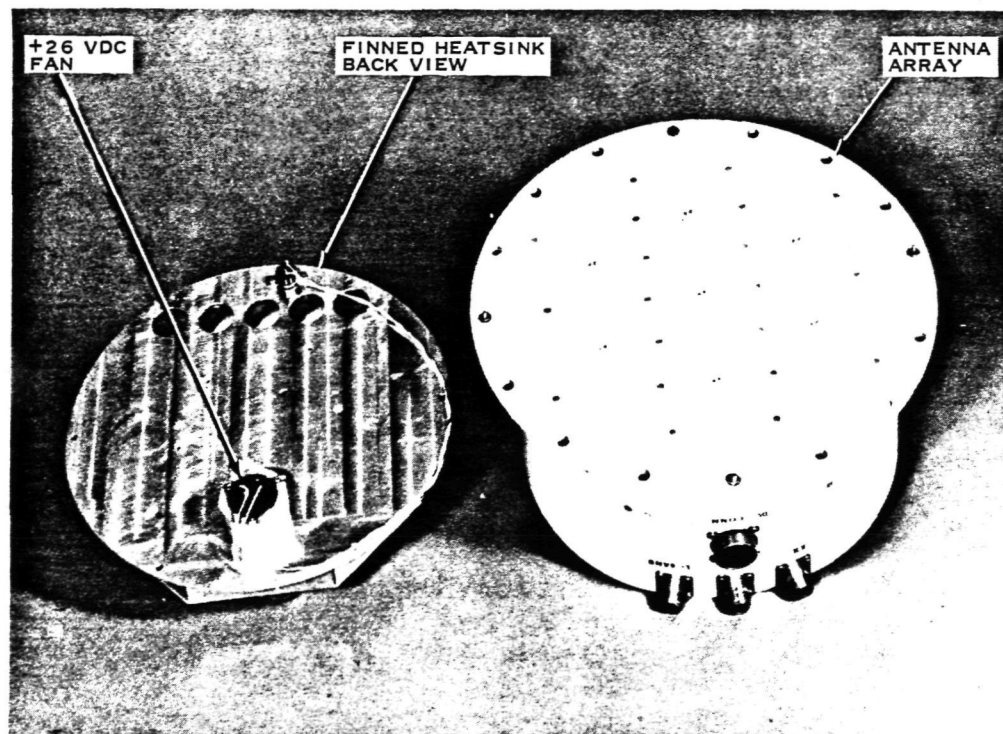


Figure 5-4. SPACS II Antenna Subsystem, Front View

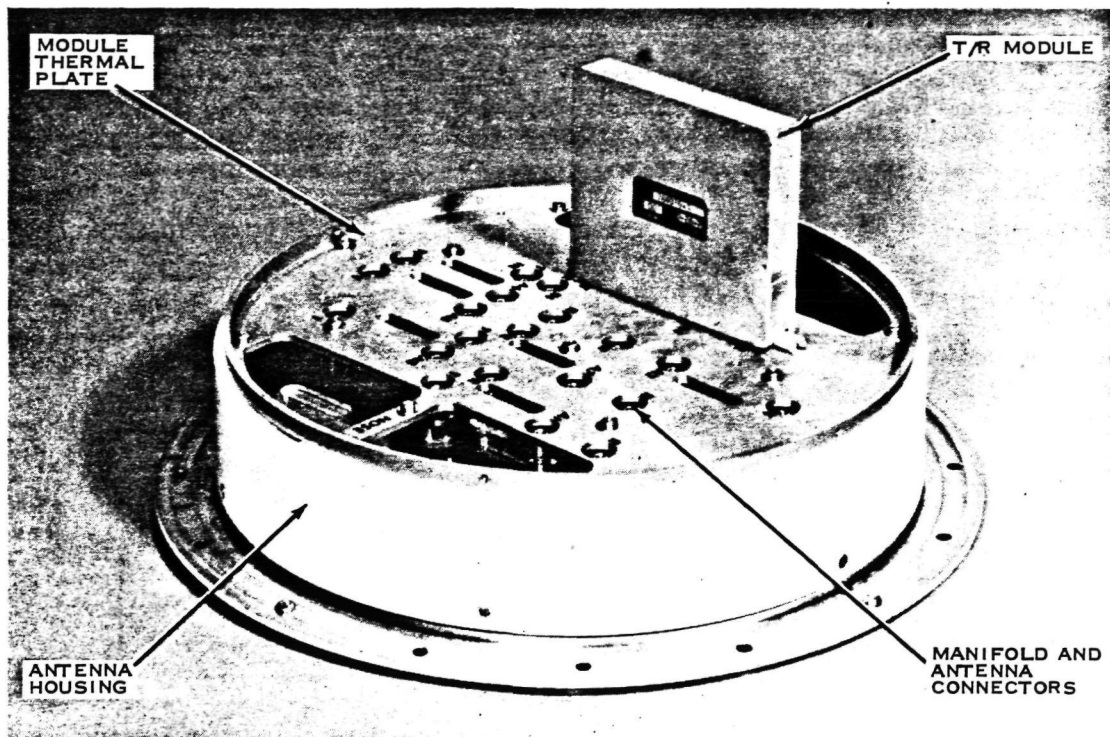


Figure 5-5. SPACS II Antenna Subsystem,
Partially Assembled



ground plane (Figure 5-6) which was then attached to an antenna positioner on antenna range number 4 (Figure 5-7).

Standard microwave signal generators and amplifiers were used to drive the array and standard gain reference horns. The SPACS II array was powered from commercial power supplies located on the ground. The dc and logic signals were supplied to the array at the top of the positioner boom through a special 35-foot umbilical cord. The dc and logic signals were generated and controlled by two manual control boxes located on the ground.

The SPACS II antenna array subsystem was tested according to test procedure SKDD401 (Appendix E). Final data is summarized on the data sheets included in this appendix.

The four antenna array S-band transmit patterns for the subsystem are shown in Figure 5-8; the four S-band receive patterns are shown in Figure 5-9, and the four central (single) element L-band receive patterns are shown in Figure 5-10.

Table 5-1 contains a summary of these patterns. Compare these results with the array design goals listed in Table 2-1. The S-band transmitter EIRP design goals are 24 dBW on boresight and 18 dBW for 50- and 70-degree scan angles in the roll and azimuth planes respectively. The array comes very close to meeting these requirements within the measurement accuracy of the test equipment. The S-band receiver gain design goals are 31.5 dB on boresight and 25.5 dB at 50- and 70-degree scan angles in the roll and azimuth planes respectively. The array exceeds these goals by at least 8 dB. The L-band receive gain design goal was a 0-dB gain omni antenna followed by a 4-dB module loss and a 0.5-dB cable and connector loss. According to the data in Table 5-1, these figures are also very close to the design goals.

C. SUMMARY AND RECOMMENDATIONS

A review of the SPACS II antenna array subsystem antenna patterns and data shows that overall performance is good. The transmitter gain and EIRP values are very close to the design goals, and the receiver gain values greatly exceed the design goals. In general, array integration and tests went smoothly.

The following recommendations are suggested for future studies and tests on the array subsystem:

1. Obtain more antenna data at additional frequencies and planes of cut off the major axis.
2. Conduct antenna noise figure (or temperature) measurements.
3. Measure array dynamic steering performance. Look for changes in phase and amplitude performance.

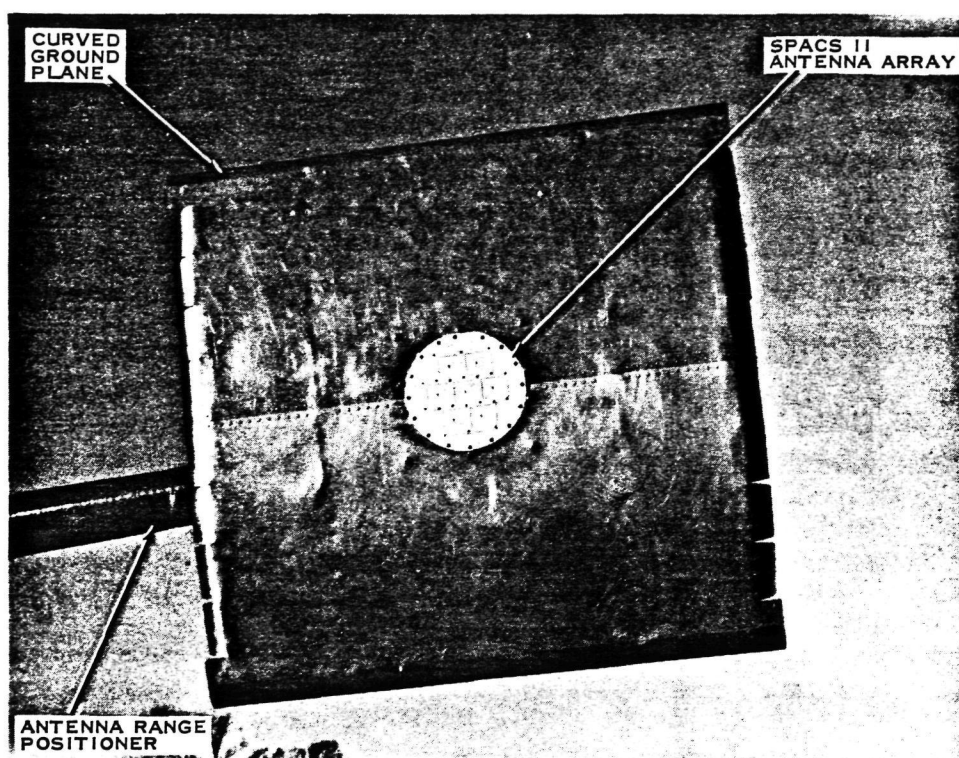


Figure 5-6. SPACS II Antenna Array Subsystem,
Mounted in Curved Ground Plane

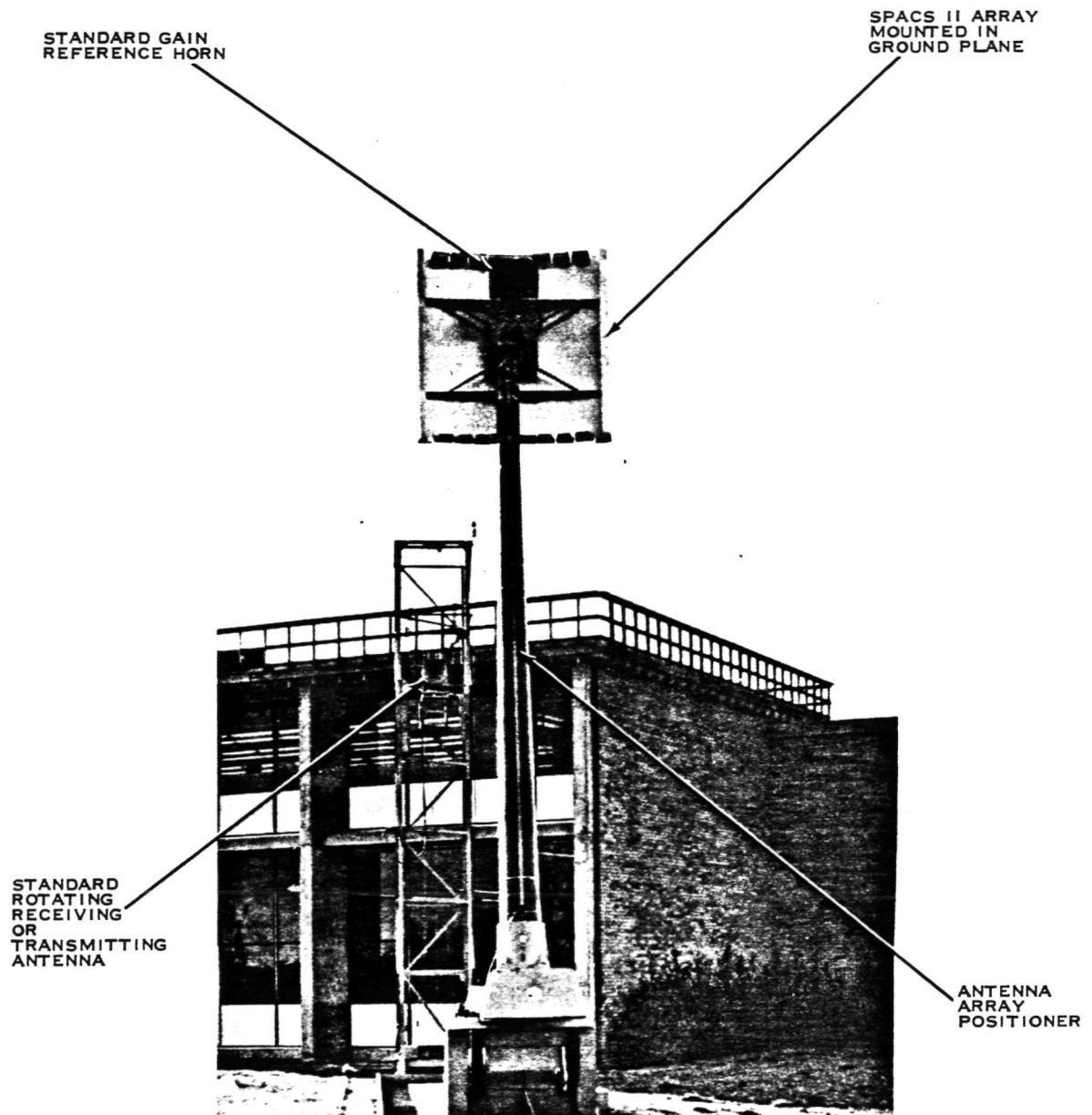


Figure 5-7. Antenna Range Number 4 with
SPACS II Antenna Array

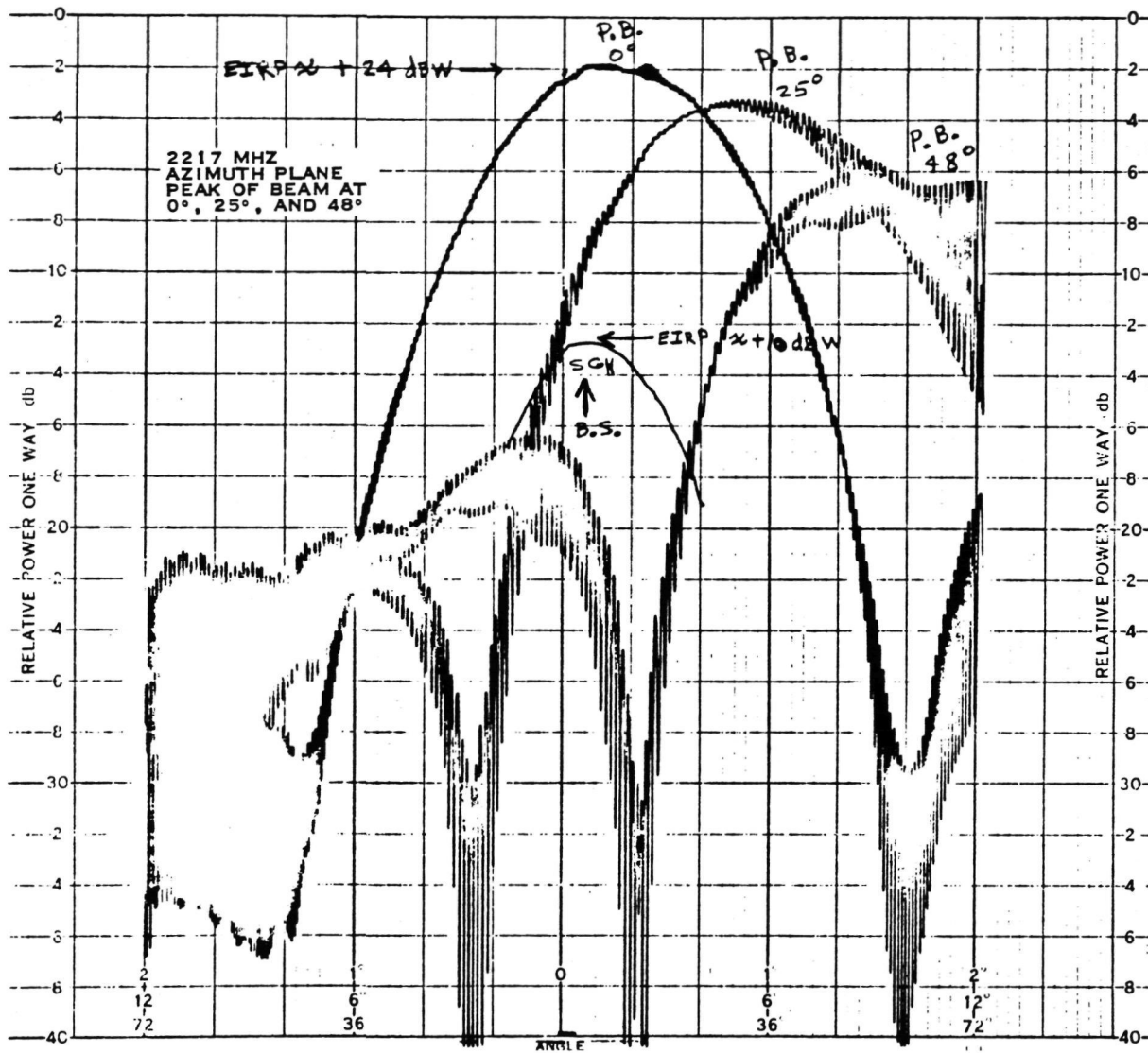


Figure 5-8. SPACS II Seven-Element Antenna Array
Subsystem Transmit Patterns
(Page 1 of 4)

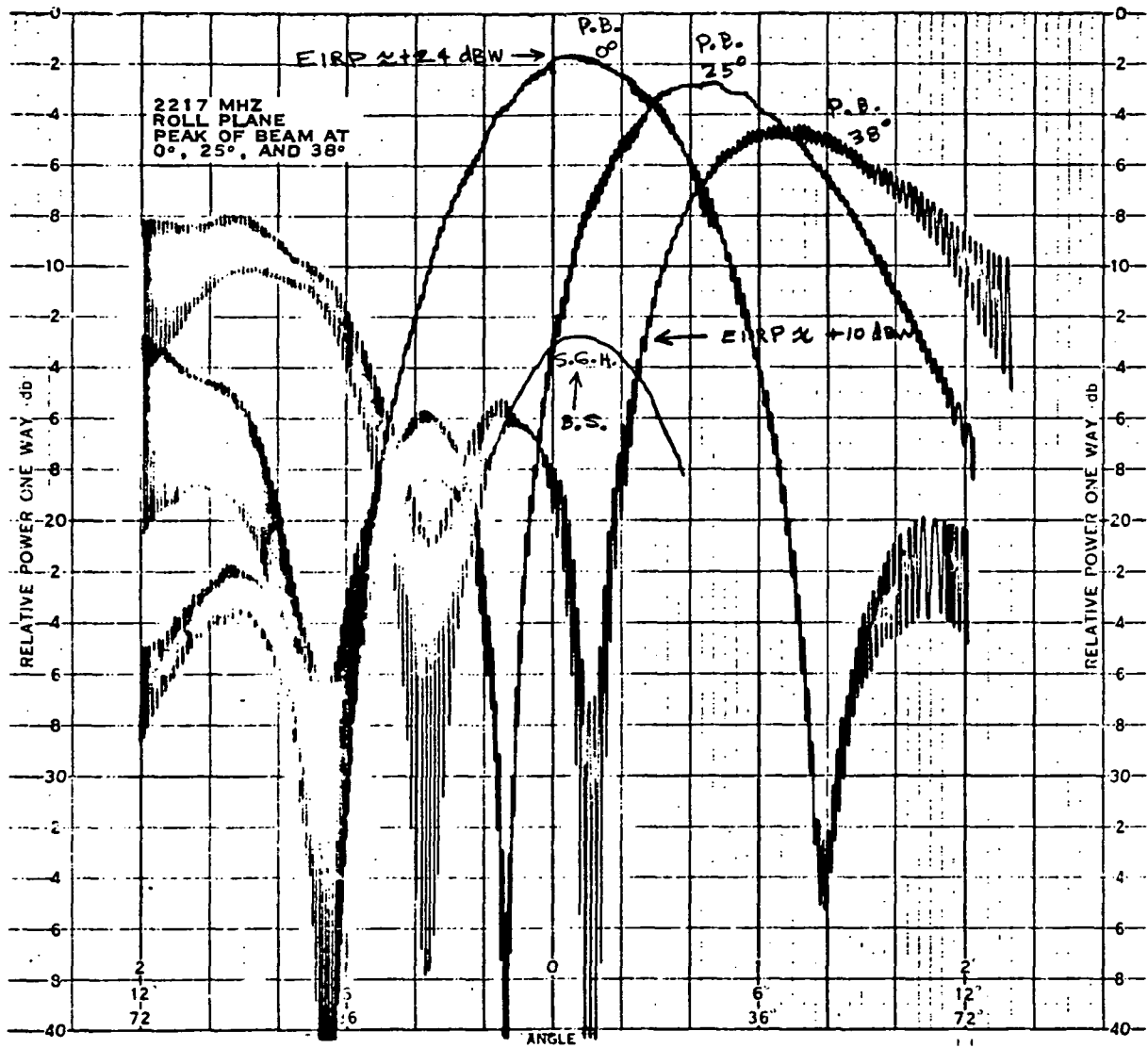


Figure 5-8. (Page 2 of 4)

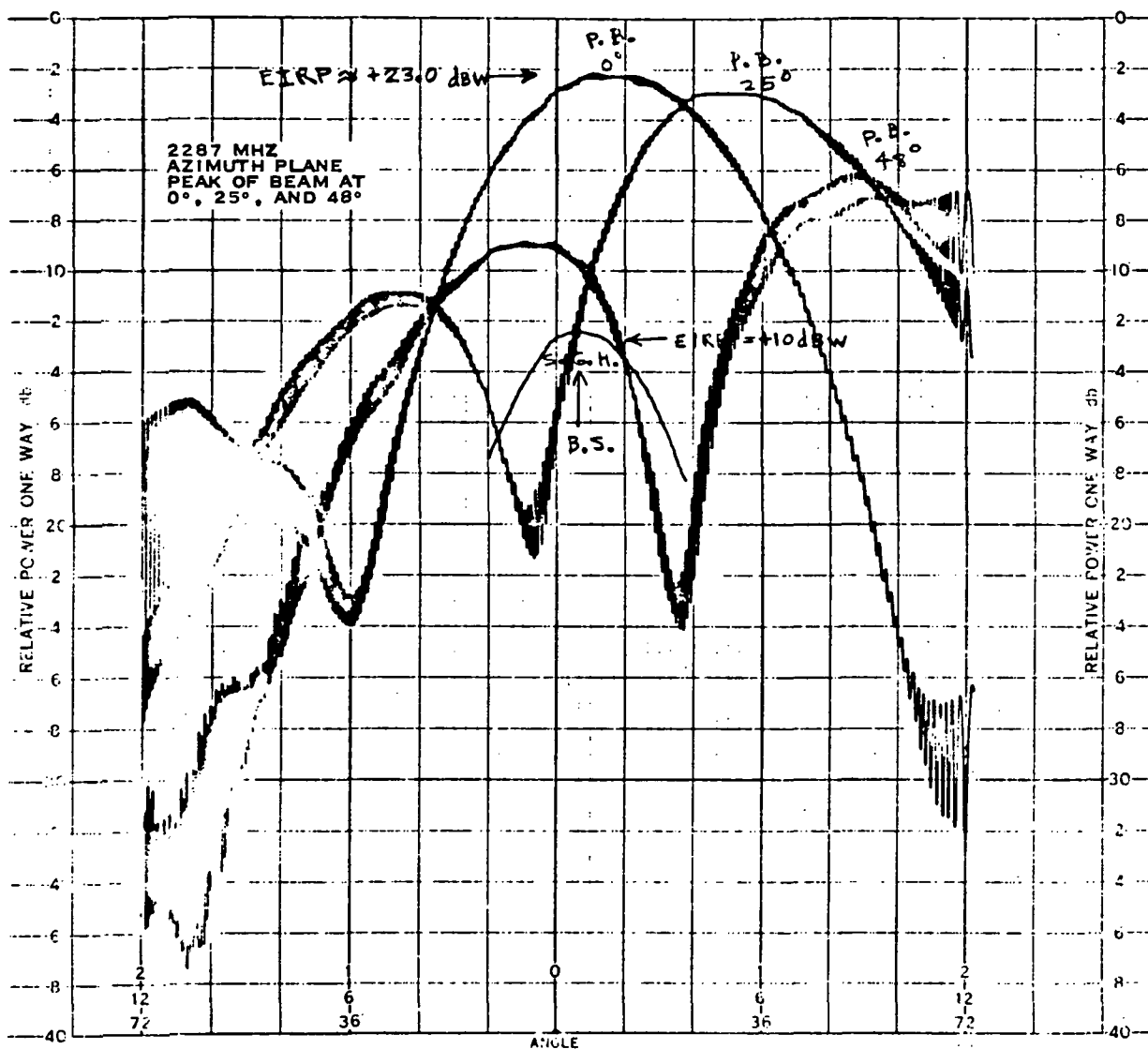


Figure 5-8. (Page 3 of 4)

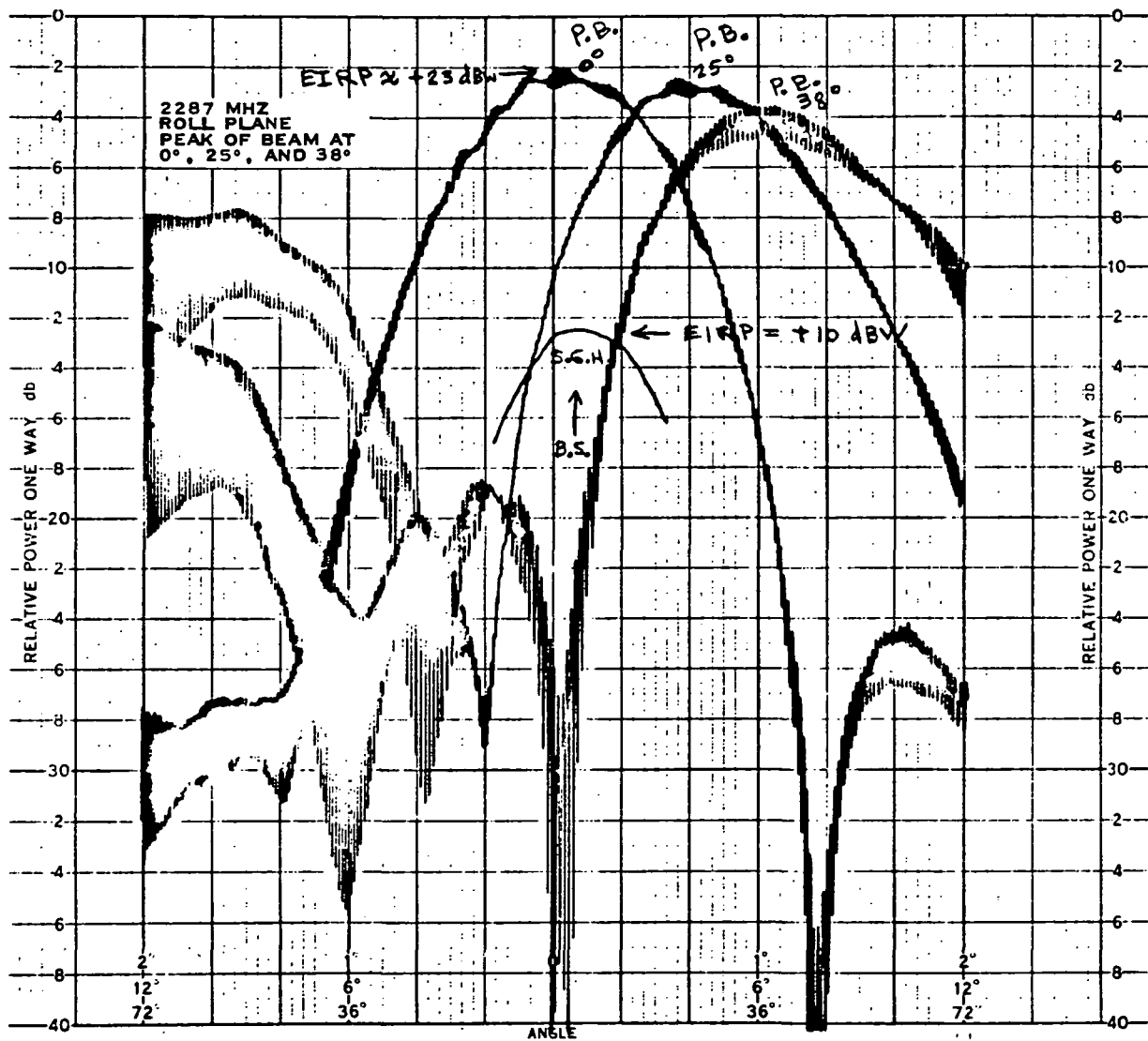


Figure 5-8. (Page 4 of 4)

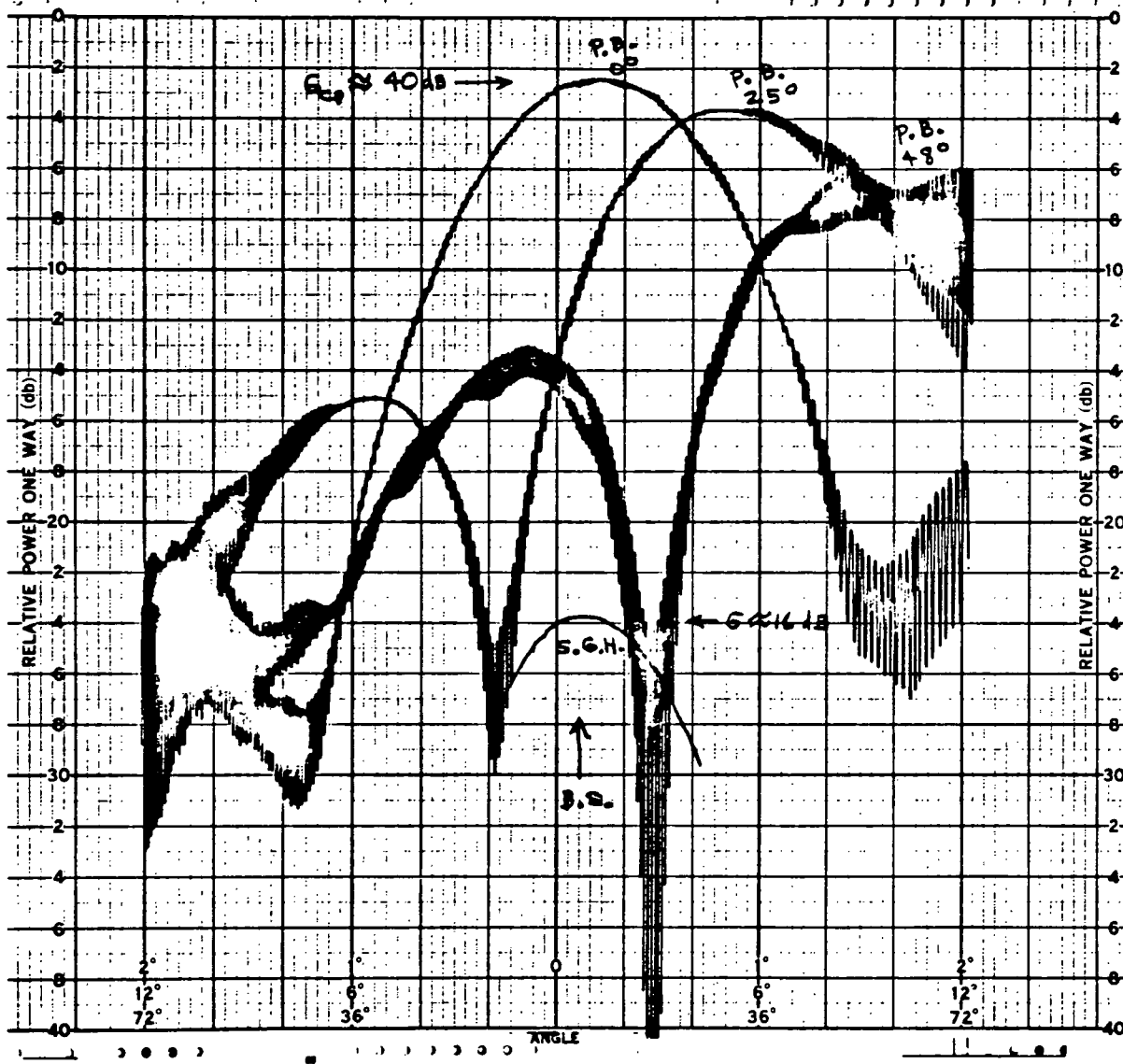


Figure 5-9. SPACS II Seven-Element Antenna Array
Subsystem Receive Patterns
(Page 1 of 4)

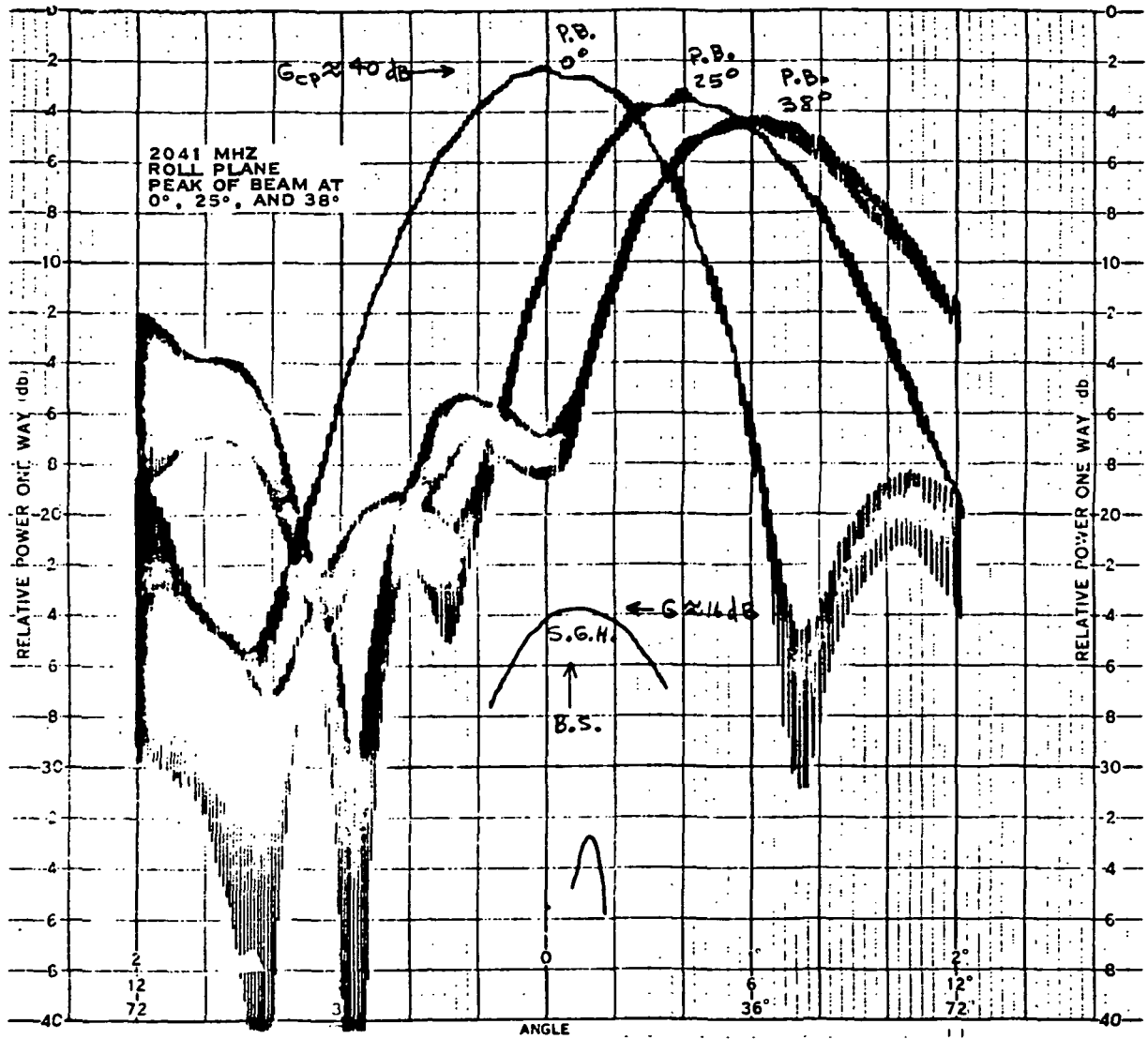


Figure 5-9. (Page 2 of 4)

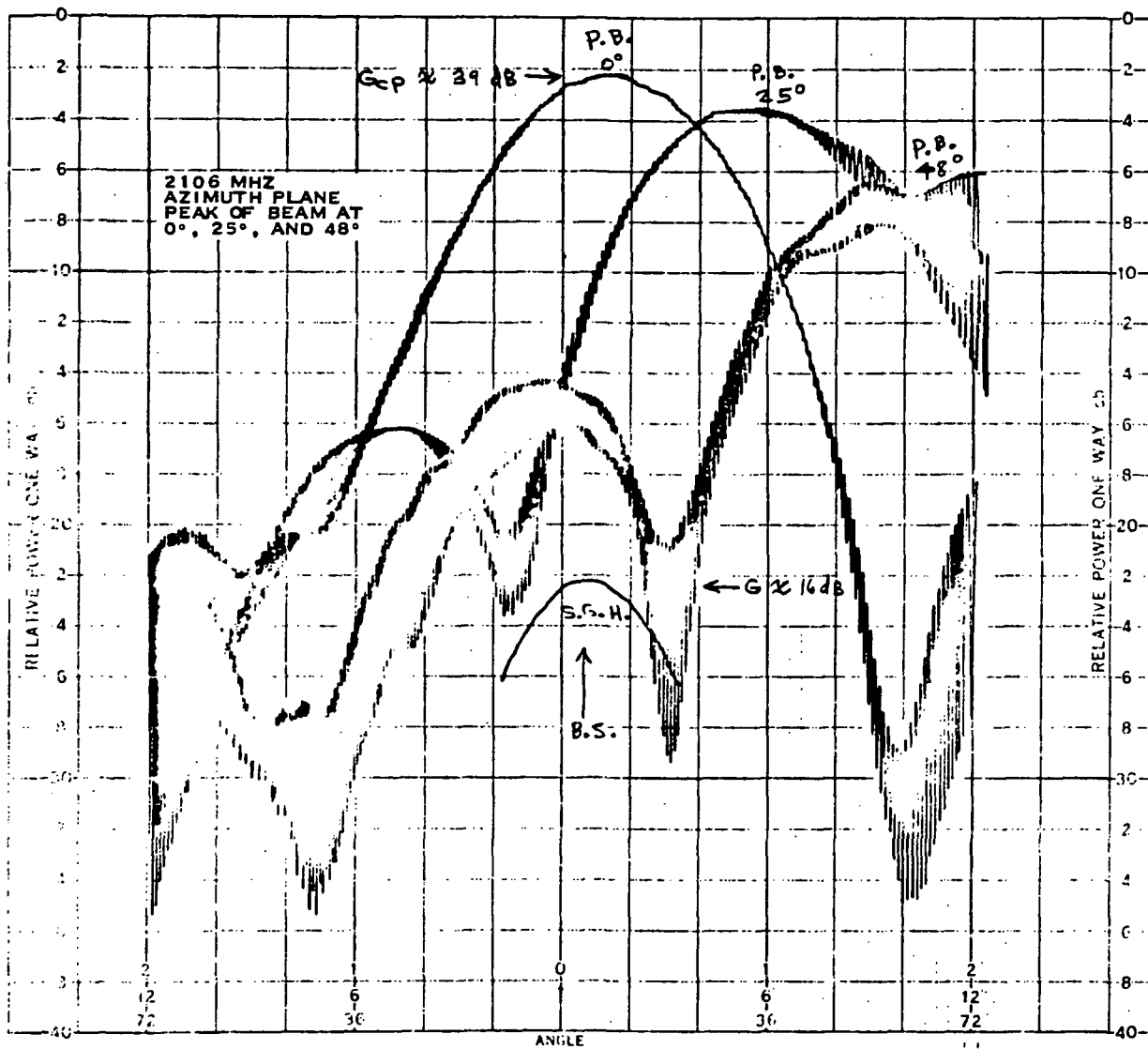


Figure 5-9. (Page 3 of 4)

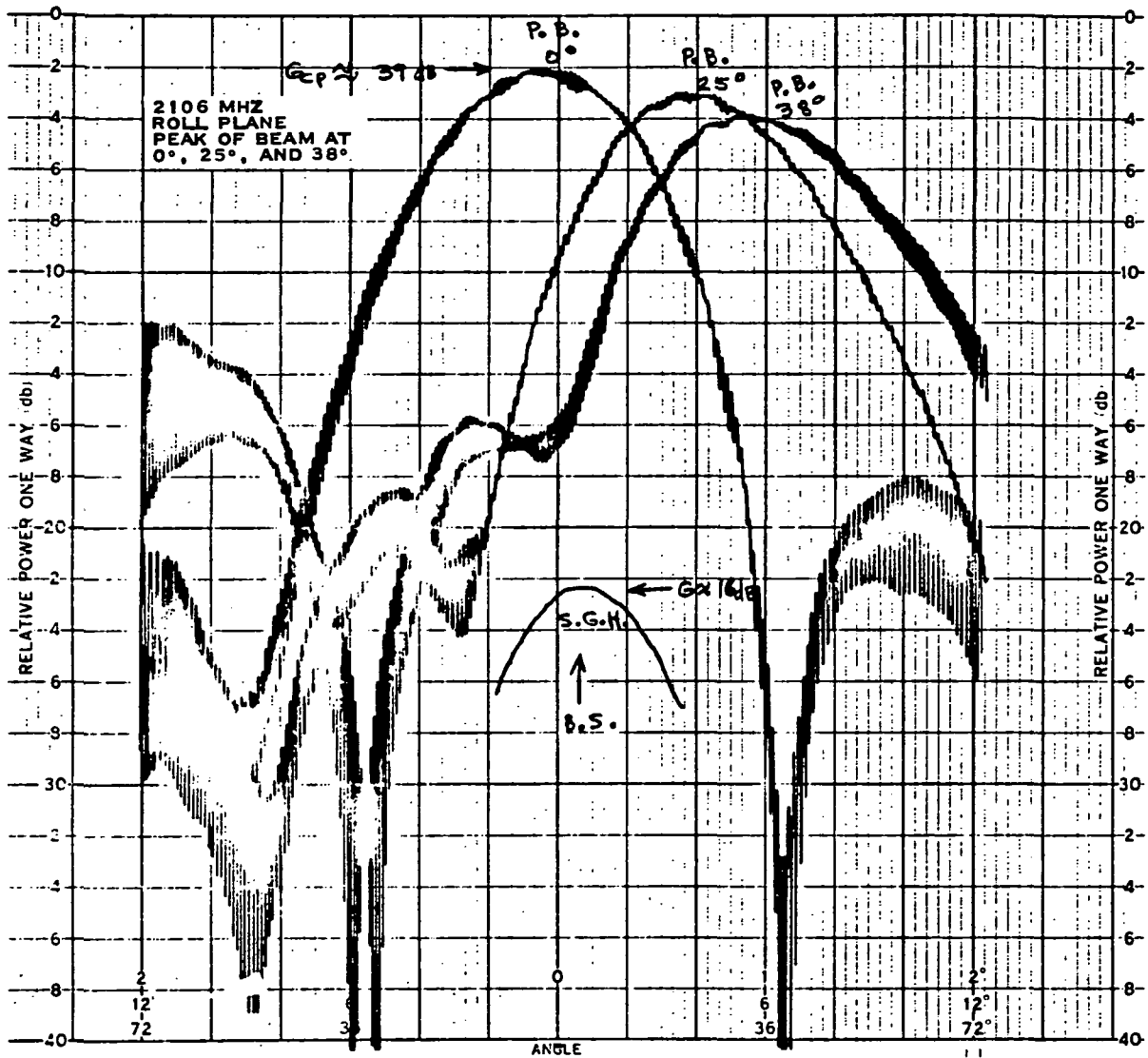


Figure 5-9. (Page 4 of 4)

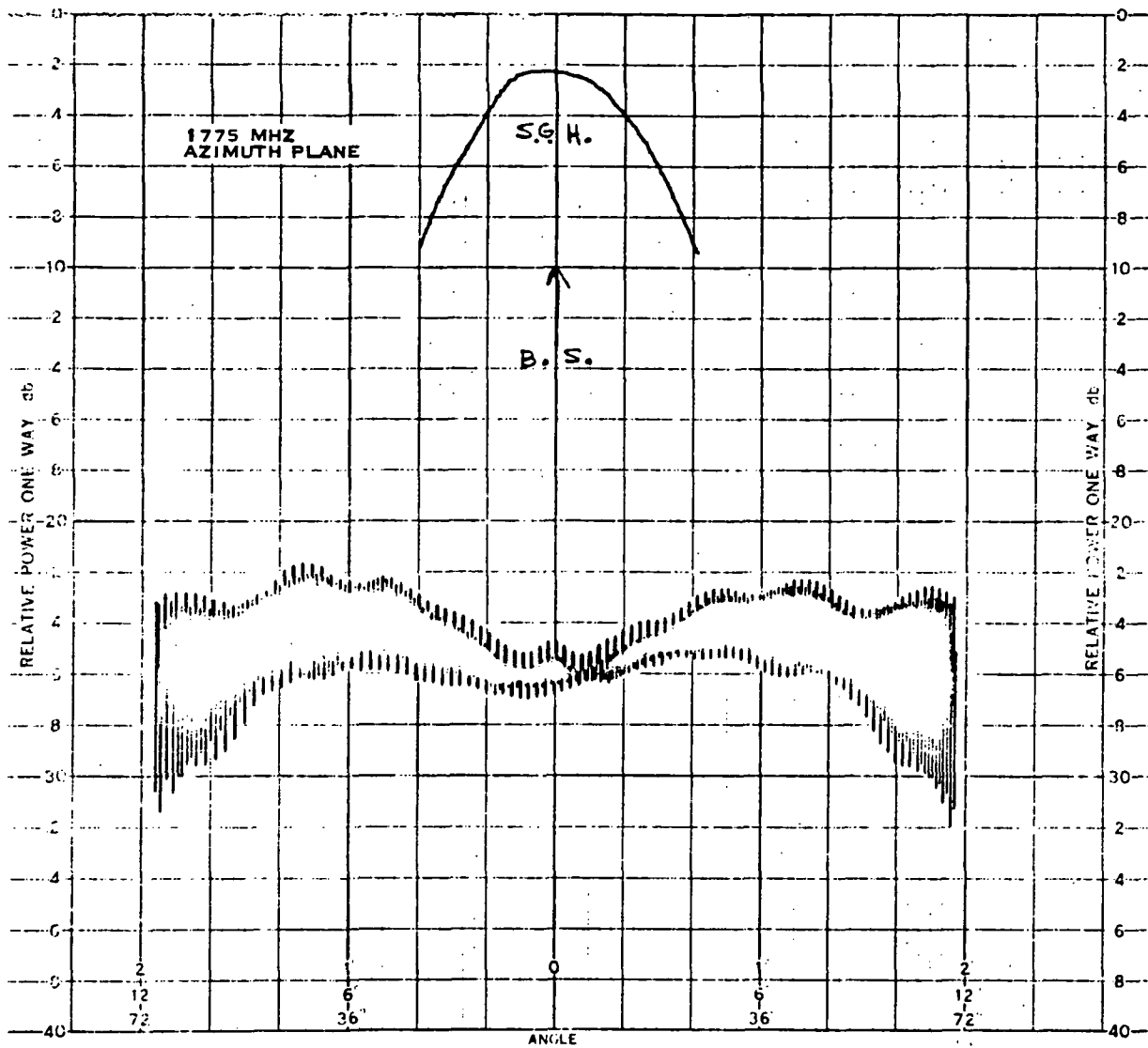


Figure 5-10. SPACS II Array, Central (Single)
Passive Antenna Element Receive Patterns
(Page 1 of 4)



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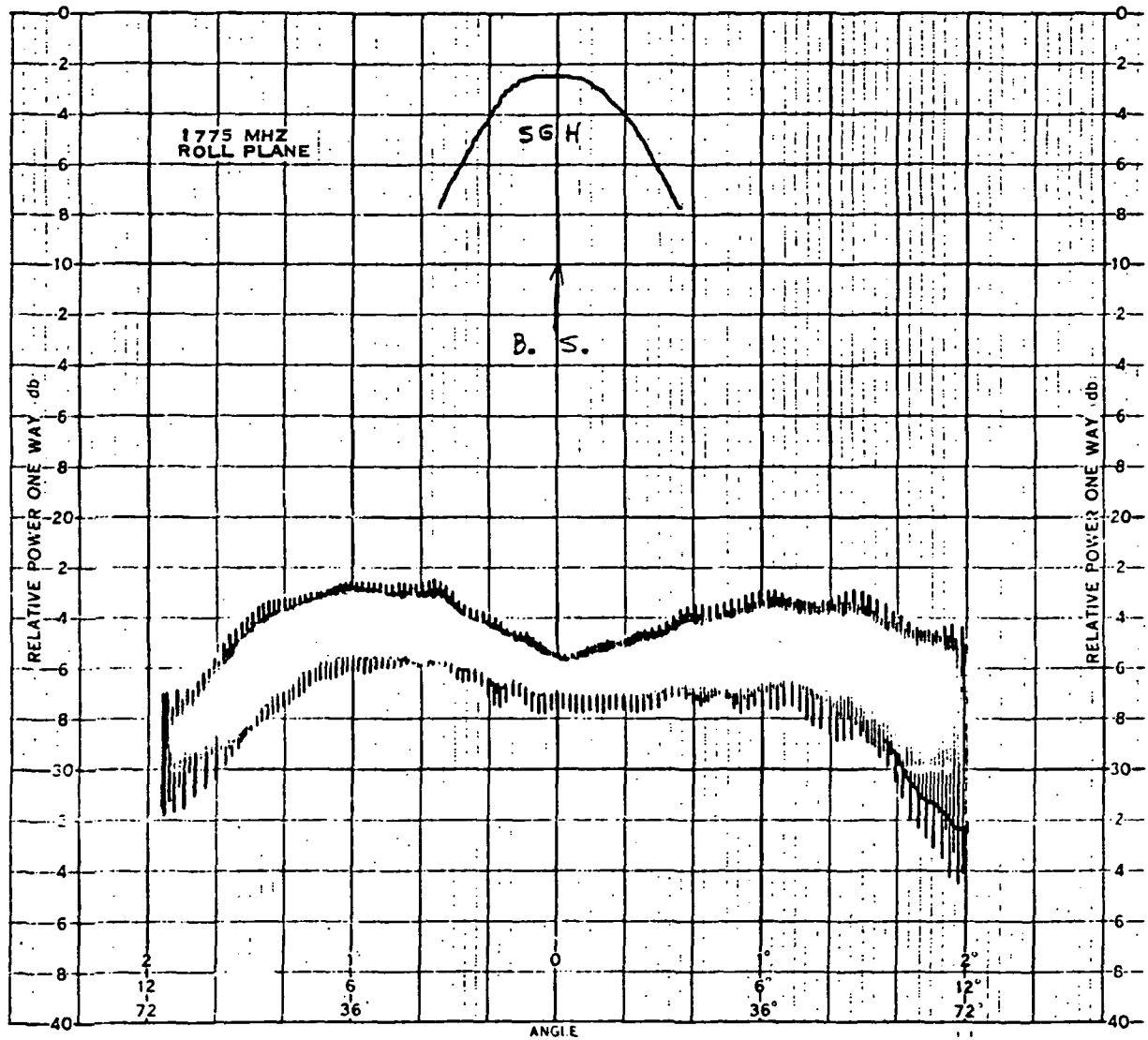


Figure 5-10. (Page 2 of 4)

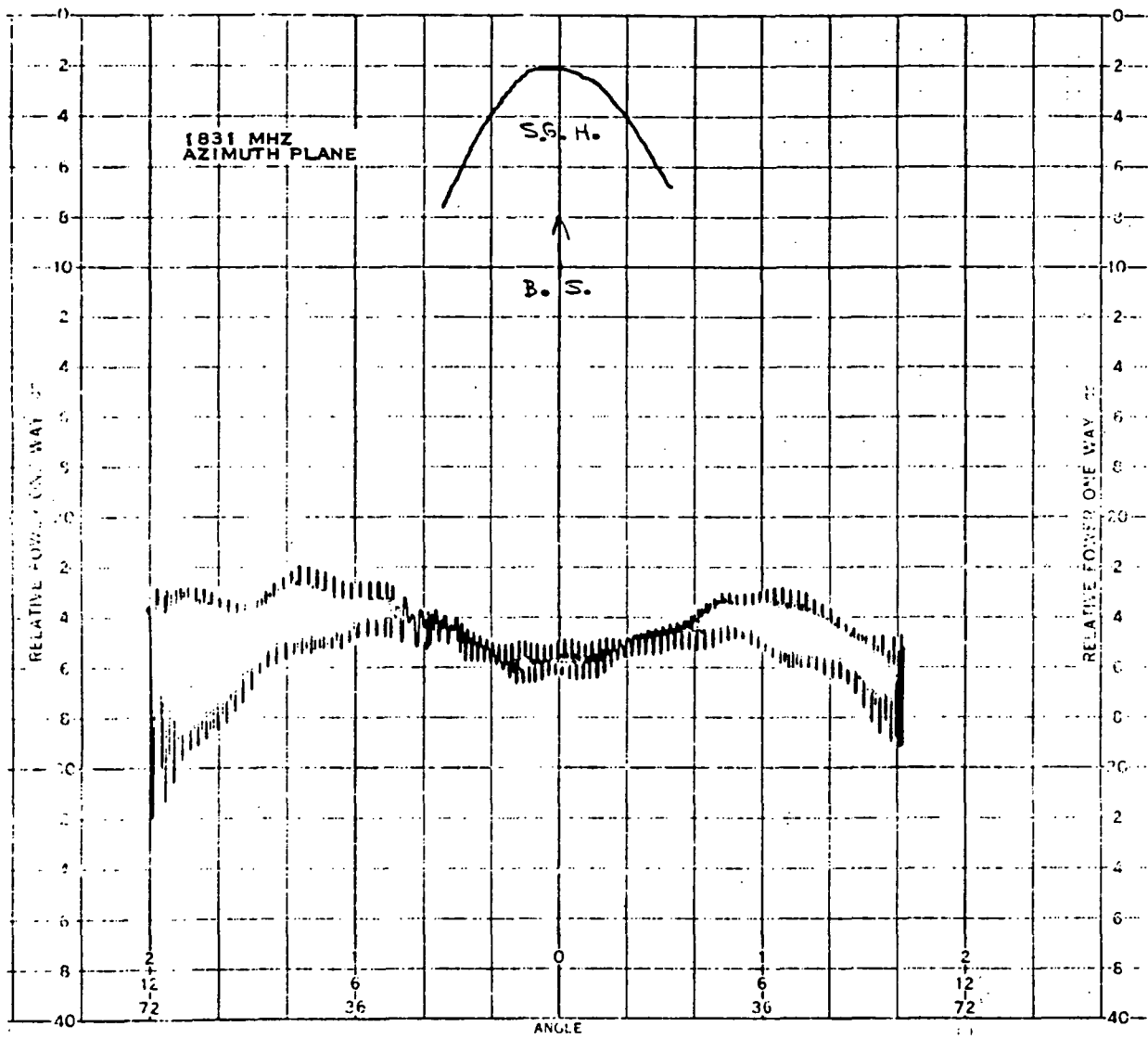


Figure 5-10. (Page 3 of 4)

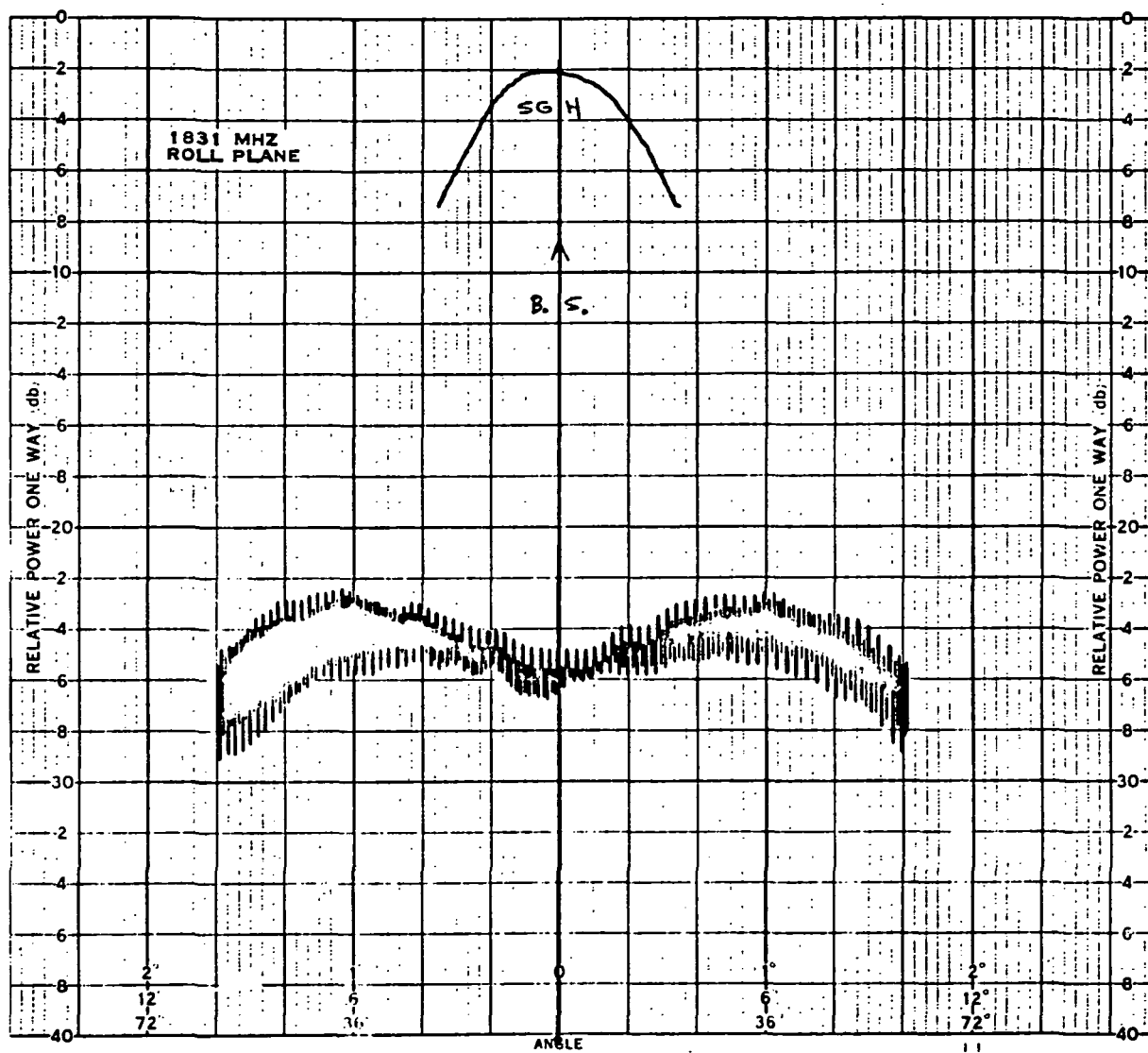


Figure 5-10. (Page 4 of 4)



Table 5-1. Summary of SPACS II Antenna
Array Subsystem Performance

Frequency (MHz)	Plane of Cut	Scan Angle (degrees)	Gain G_{cp} (dB)	Transmit EIRP (dBW)
A. S-Band Transmit		Azimuth plane		
2217.5		0	30.0	23.5
2217.5		35	28.1	21.6
2217.5		70	24.0	17.5
2287.5		0	29.4	22.9
2287.5		35	28.4	21.9
2287.5		70	23.8	17.3
B. S-Band Transmit		Roll plane		
2217.5		0	30.2	23.7
2217.5		25	28.2	21.7
2217.5		50	26.5	20.0
2287.5		0	29.3	22.8
2287.5		25	28.6	22.1
2287.5		50	26.2	19.7
C. S-Band Receive		Azimuth plane		
2041.9		0	39.9	
2041.9		35	38.4	
2041.9		70	34.2	
2106.4		0	38.6	
2106.4		35	37.1	
2106.4		70	33.1	



Table 5-1. (Continued)

Frequency (MHz)	Plane of Cut	Scan Angle (degrees)	Gain G_{cp} (dB)	Transmit EIRP (dBW)
D. S-Band Receive		Roll Plane		
2041.9		0	39.7	
2041.9		25	38.6	
2041.9		50	36.2	
2106.4		0	38.3	
2106.4		25	37.9	
2106.4		50	34.6	
E. L-Band Receive		Azimuth plane		
1775.5		0	-5.5	
1775.5		35	-3.3	
1775.5		70	-5.0	
1831.8		0	-4.0	
1831.8		35	-3.5	
1831.8		70	-5.0	
F. L-Band Receive		Roll plane		
1775.5		0	-5.8	
1775.5		25	-4.2	
1775.5		50	-4.2	
1831.8		0	-6.5	
1831.8		25	-4.0	
1831.8		50	-4.3	



-
4. Find the optimum steering algorithms to reduce phase transients.
 5. Experiment with the shuttle TPS material in front of the array to study any effects on gain, phase, and antenna patterns.
 6. Transmit and receive phase-modulated signals through the array to study the effect of the array on signals.
 7. Perform array receive experiments using spread spectrum signals to see the effects of the array.



SECTION VI

SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

This section summarizes the October 1975 status of the phased array development work for NASA Johnson Space Center under contract NAS9-14485. The example array application is the Space Shuttle Orbiter. The phased array development is known by the acronym SPACS which stands for S-band phased array communication system. SPACS was developed as a research program to improve the operation of the TDRSS to orbiter link and provide data with which to compare the baseline system. If adopted, it would be a part of the S-band network equipment.

The S-band communication system on the Space Shuttle is the voice and data link between the Shuttle and TDRSS (relay) satellite.

B. ENGINEERING MODEL SPACS II ANTENNA ARRAY SUBSYSTEM

The following list presents the four major tasks required by this contract:

1. Fabricate and test five outer modules identical to the one designed and built under NASA contract NAS9-14196.
2. Design, build, and test a center module with additional L-band receive capability and having no S-band transmit or receive phase shifters.
3. Design, build, and test a dc and logic multilayer manifold compatible with array and module requirements.
4. Integrate all hardware built under NASA contracts NAS9-14196 and NAS9-14485 into an antenna array subsystem and perform the major antenna tests on this subsystem.

All these tasks were completed and a summary of these tasks has been discussed in this report. Overall, the performance on these tasks was very good.

Table 6-1 shows an abbreviated description of the SPACS performance based on SPACS II measurements. Unlike a mechanically scanned antenna, the gain of an electronically scanned antenna varies with scan. The values of the figures of merit employed, EIRP, and gain noise temperature figure contain this variation and are stated as worst case values at the edge of coverage as well as at the broadside. Gains and module power outputs used in Table 6-1 were measured in August 1975 at Texas Instruments.



Table 6-1. Summary of SPACS II System Performance

Seven-element S-band antennas spaced at 90-degree intervals about the spacecraft (four)

Minimum EIRP over a 100 by 140 degree cone	17.5 dBW
Maximum EIRP at broadside	24 dBW
Input power level	30 dBm at switch input (1 watt)
Minimum gain/noise temperature over a 100 by 140 degree cone	-25 dB/°K
Maximum gain/noise temperature at broadside	-18 dB/°K
Receive electronic gain	30 dB
DC power	196 watts (22 to 30 volts), including steering controllers
Weight	17.0 pounds each array (four arrays)
Transmit frequencies	2217.5 and 2287.5 MHz
Receive frequencies	2041.9, 2106.4 MHz 1775.9, 1831.8 MHz
Dimensions	10.68-inch diameter by 7-inch height

Power conditioner/coordinate converter

Provides conditioned dc voltages to each array

Converts pointing angles for the system into array angles for correct phasing of modules



C. RISK AREAS AND IMPROVEMENTS

The only possible risk areas for a SPACS II array are thermal environment and vibration specifications. Under the thermal boundary conditions defined for the array in this contract, a low volume liquid loop from the vehicle is necessary to maintain the required temperature range of the array. With this liquid loop, all worst case missions can be met. If a liquid loop cannot be supplied, several worst case hot temperature conditions could not be met, but the majority of normal (nominal) flight missions could be met using an array self-contained liquid loop mounted to the bondline of the aircraft.

Further thermal definition and study should be conducted in coordination with NASA thermal designers to set all boundary conditions and thermal design methods. The thermal liquid loop is not a great risk, but more design work should be done to complete design details and control methods.

The vibration requirements during reentry and launch could be a problem depending upon the level of vibration and axis of vibration. The present SPACS II array is designed for use in fighter-type aircraft (MIL-E-5400 vibration specifications). Further study, definition, and design should be done to ensure the SPACS flight model meets all NASA shuttle vibration requirements. This does not appear to be a serious risk area.

Numerous improvements on the SPACS II breadboard mechanical, electrical and reliability performance can be made. It was not the intent of this research contract to build a flight-qualified item. Some areas for future improvements are reduced system weight, lower system power (higher efficiencies in module), lower system noise temperature, and increased antenna gain. All these areas can be improved with further work.

D. SUMMARY AND CONCLUSIONS

The initial work on this development was formulated in the fall of 1973 during a technical discussion at NASA Johnson Space Center. The contract known as SPACS I, NAS9-14196, was initiated in early summer of 1974 for development of the antenna, feed networks and prototype module. In early 1975, subsequent scope was added which called for the construction of additional modules. That additional scope is shown in the schedule in Table 6-2. This second contract (SPACS II, NAS9-14485) was completed in October 1975. A summary of the major antenna array subsystem performance for this contract is shown in Table 6-3.

The development of the SPACS array is an outgrowth of the technology developed for NASA MSFC under contract NAS8-25847 by Texas Instruments and the hardware under this MSFC contract was used to the maximum extent possible.

This SPACS II program was very successful and the majority of all design goals were met. The system design outlined and detailed in this final report appears to be a very competitive approach for the S-band communication system



Table 6-2. SPACS Contract Schedule

CURRENT STATUS (1 October 1975)

SPACS I Program

Developed and Tested

Seven-element antenna
RF feed networks
One breadboard outer module

Data

Monthly reports
Final report
New technology report

SPACS II Program

Developed and Tested

Development and delivery of one center module
Development and delivery of five additional outer modules
Development of a dc and logic manifold
Integration and testing of the antenna array subsystem

Schedule

Contract received	3 January 1975
Received all parts	15 May 1975
Completed module assembly and test	15 July 1975
Completed dc feed network	15 June 1975
Completed antenna subsystem tests	15 August 1975
Final report	15 October 1975

Data

Monthly reports
Final report
New technology report



Table 6-3. SPACS II Major Antenna Subsystem Parameters

Transmitter at 2217.5 MHz and 2287.5 MHz

EIRP, minimum, 70- by 50-degree elliptical scan	17.5 dBW
EIRP Boresight	24 dBW
Gain (electronic)	22 dB minimum

Receiver at 2041.9 MHz and 2106.4 MHz

Gain (electronic + antenna)	33 dB minimum
Noise figure (estimate)	6 dB nominal

Antenna Beamwidth 38 degrees (nominal)

L-Band Receive at 1775.5 MHz and 1831.8 MHz

Center antenna gain	0 dB (nominal)
Module and cable loss	4 dB (nominal)

Array Body Diameter 10.68 inches maximum

Array thickness (including finned heatsink and fan) 7 inches

Weight 17 pounds nominal

DC power (total array)	+22 Vdc at 5.5 amperes maximum
	+12 Vdc at 0.4 amperes maximum
	+5 Vdc at 0.6 amperes maximum

Total power input = 130 watts



for the Space Shuttle. In many areas, the SPACS system offers significant advantages over omni and passive phased array systems.

Areas for future development are a triplexer module, a steering (logic) controller, and dc power conditioner and coordinate converter unit. Texas Instruments will welcome the opportunity to expand the technical foundation laid in this effort. We are confident that continued development of the type of spacecraft antenna array described herein will lead to a useful flight subsystem applicable to a number of spacecraft uses including Space Shuttle, Space Tug, and Shuttle Payload experiments.



APPENDIX A

A-1

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
SK784010-1	1207				
SK446962-1	1207				

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS
MODULE TEST PROCEDURE FOR
OUTER MODULES (P/N SK784010-1) AND FOR
CENTER MODULES (P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

[illegible]

A-1

SPACS II - TRANSMIT/RECEIVE MODULE TESTING

I. INTRODUCTION

The purpose of this document is to describe the test procedure for the SPACS II transmit/receive microelectronics module. This measured data is to be compared to the design parameters as defined in statement of work by paragraphs 3.1 through 3.2.2.5 of the contract NAS9-14485. A summary of these requirements is shown in the appendix of this test procedure.

II. MODULE TRANSMITTER TESTS

The transmitter side of the module will be tested using a Hewlett-Packard Automatic Network Analyzer (ANA) Model 8542A modified for high power measurements. The measurement will be controlled by a Texas Instruments developed software program (APAM1-1, Automatic Power Amplifier Measurement) based upon the HP8540 software series.

The test setup for this transmitter test is shown in Figure 1. An example ANA printout is shown by Figure 2. The device under test shown in Figure 1 will be the transmitter side of the SPACS II module.

In addition to the data shown by the printout of Figure 2, current on each of the power supply lines (+5V, +12V, and +22 volts) will be recorded from VOM readings at the minimum (0°) phase setting for each power level. A summary of this data will be recorded on the data sheets in SKDD302 labeled Table I. The data will be taken at room temperature (25°C) only.

III. MODULE RECEIVER TESTS

The receiver side of the module will be tested using a Hewlett-Packard Automatic Network Analyzer (ANA) Model 8542A under small signal conditions. The measurement will be controlled by a HP software program AGS03.

This measurement will use the same test setup as shown in Figure 1 with the exception of substitution of the HP 8746 Test Unit for the HP 8745 Test Unit. An example printout of the type of data measured is shown by Figure 3. The device-under-test shown in Figure 1 will be the receiver side of the SPACS II module.

In addition to the data shown by the printout of Figure 3, current on the power supply lines (+12V and +5 volts) will be recorded from VOM readings at the minimum (0°) phase setting. Power input to the antenna connector of the module will be -40 dBm to insure that the receiver amplifier is being operated in its linear (uncompressed) region.

A summary of this data will be recorded on the data sheet in SKDD302 labeled Table II. The data will be taken at room temperature (25°C) only.

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 2

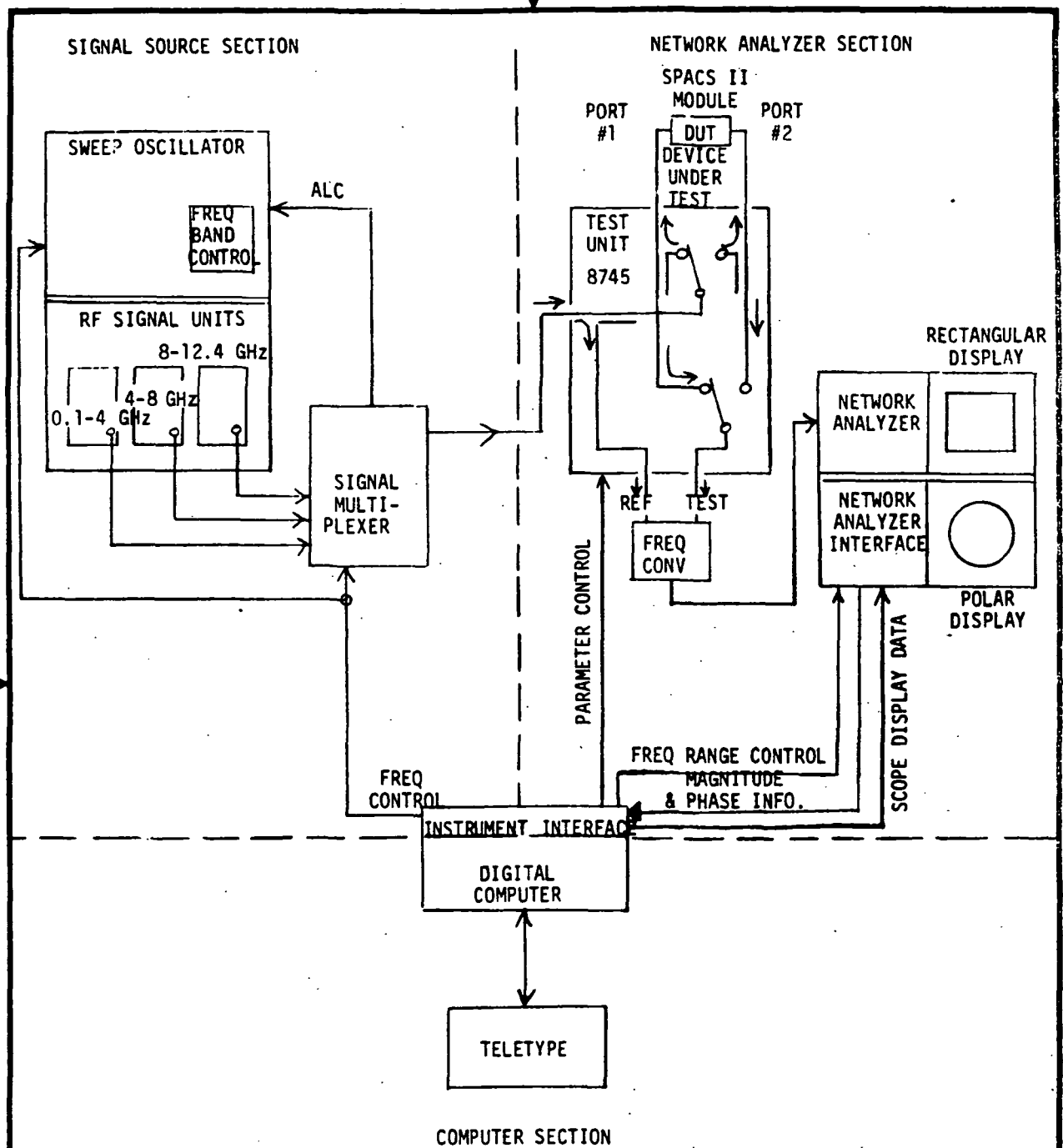


FIGURE 1. AUTOMATIC NETWORK ANALYZER SYSTEM (HP8542A)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 3

TASK, TYPE? 2,1

[INPUT POWER LEVEL CORRECTION FACTOR, ADD +6 DBM
GAIN CORRECTION FACTOR, ADD +23 DB
OUTPUT POWER CORRECTION FACTOR, ADD +29 DBM]

NEW MEAS? Y

CONN DEVICE...0 DEGREES

SPACS II MODULE - TRANSMITTER SECTION

FREQ	REFL	VSWR	P IN	GAIN	PHASE	P OUT
POWER LEVEL = 6.00 DBM						
2217.500	.108	1.241	6.00	.32	-91.8	6.32
2252.500	.215	1.549	5.97	1.41	75.5	7.37
2287.499	.382	2.235	5.98	-.23	-104.3	5.74
POWER LEVEL = 7.00 DBM						
2217.500	.177	1.431	6.96	-.48	-89.3	6.48
2252.500	.165	1.395	7.01	.63	77.4	7.63
2287.499	.324	1.959	6.99	-.23	-110.8	6.76
POWER LEVEL = 8.00 DBM						
2217.500	.238	1.626	8.01	-1.42	-97.3	6.59
2252.500	.180	1.438	7.99	-.23	78.6	7.75
2287.499	.259	1.699	7.96	-.76	-112.9	7.20

GRADE = 51.665

FIGURE 2. ANA PRINTOUT FOR TRANSMITTER MEASUREMENT (APAM1-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 4

2,1

INPUT POWER = -40 DBM
GAIN CORRECTION FACTOR = ADD +30 DB

NEW MEAS? Y

CONN DEVICE...45 DEGREES SPACS II MODULE-RECEIVER SECTION

FORWARD:

FREQ	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
2030.000	.521	114.6	5.7	3.171	4.59	-93.8	15.011
2041.000	.397	14.4	8.0	2.318	4.06	-153.2	14.193
2052.000	.292	-99.4	10.7	1.824	3.37	150.6	12.077
2063.000	.257	162.6	11.8	1.691	3.17	102.8	12.090
2074.000	.229	53.1	12.8	1.594	3.12	54.9	13.523
2085.000	.315	-68.2	10.0	1.918	3.25	1.3	13.540
2096.000	.450	-158.2	6.9	2.637	3.47	-52.3	13.713
2107.000	.483	110.8	6.3	2.866	3.44	-106.6	15.759
2117.999	.426	-6.7	7.4	2.486	3.55	-169.0	15.759

FIGURE 3. ANA PRINTOUT FOR RECEIVER MEASUREMENT (AGS03)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SK00301
SCALE	REV	SHEET 5

IV. RECEIVER NOISE FIGURE MEASUREMENT

The receiver side of the module will be tested using an AIL Model 75 Automatic Noise Figure Meter and an AIL Model 7010 Noise Generator. This will be a manual test using a calibrated test setup as shown in Figure 4.

This noise figure data will be recorded on the data sheet in SKDD302 labeled Table III. The data will be taken at room temperature (25°C) only. This data will be compared to module design goal of 4.87 dB noise figure; the maximum module noise figure requirement is 5.33 dB.

V. RECEIVER COMPRESSION POINT MEASUREMENT

The compression characteristic of the receiver will be tested using a manual calibrated setup as shown in Figure 5.

The 1 dB compression point will be measured and recorded on the data sheet for each of the frequencies shown in Table III of SKDD302. This compression data will be compared to the module design goal of +10 dBm at 1 dB compression point.

VI. MODULE DUPLEX OPERATION TEST

The test set shown in Figure 6 will be utilized to conduct an evaluation of the module in the fully duplexed mode. With the transmitter initially turned off, a spectrum analyzer is used to establish a -40 dBm receive signal (2041.9 MHz) at the module antenna port. The receiver output is then monitored and the output level is measured and recorded. When the transmitter is then enabled (2217.5 MHz) and operated into the 1.6:1 VSWR antenna load, the receiver output levels are again measured and recorded. Under duplex operation the receiver gain must be greater than 25 dB and there should be no more than 3 dB variation between gain with transmitter off and gain with transmitter on. The same test is repeated at the upper frequency band (transmit at 2287.5 MHz, receive at 2106.4 MHz). All this data will be summarized on the data sheet in SKDD302, Table IV.

An evaluation of intermodulation distortion will also be conducted under fully duplexed operation. The lower band test described above will be repeated with the 1.6:1 VSWR load replaced by a load VSWR less than 1.05:1. The module is fully duplexed and other frequency products will be observed to be greater than 40 dB below the receiver carrier frequency level. The 50 ohm load is replaced with the 1.6:1 VSWR mismatch and other frequency products will be observed to be greater than 20 dB below the receive carrier frequency. The intermodulation test will also be repeated at the upper frequency band (transmit at 2287.5 MHz, receive at 2106.4 MHz). No intermodulation products greater than 20 dB below the receive carrier frequency will be observed for either antenna port termination.

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 6

A-6

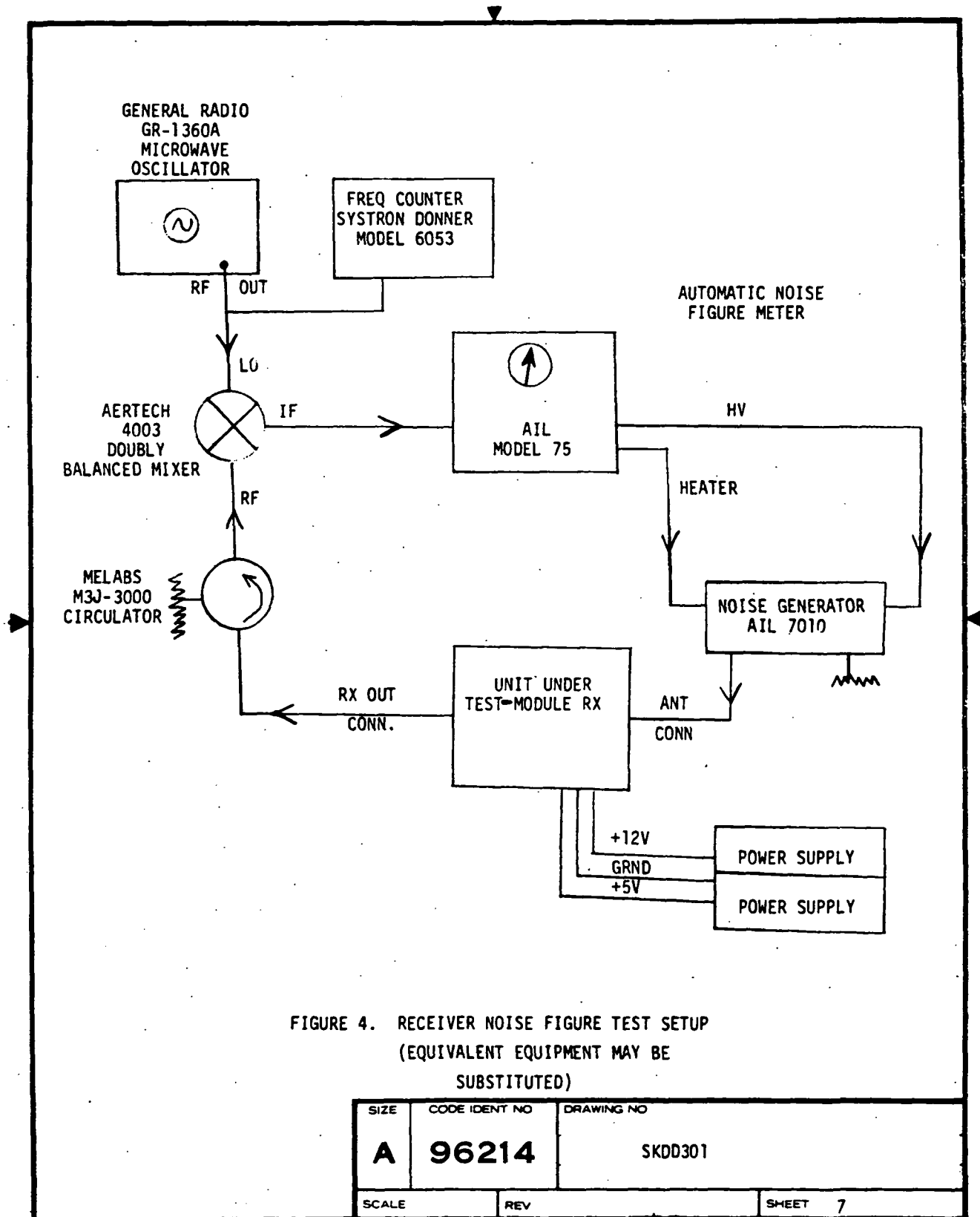


FIGURE 4. RECEIVER NOISE FIGURE TEST SETUP
(EQUIVALENT EQUIPMENT MAY BE
SUBSTITUTED)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 7

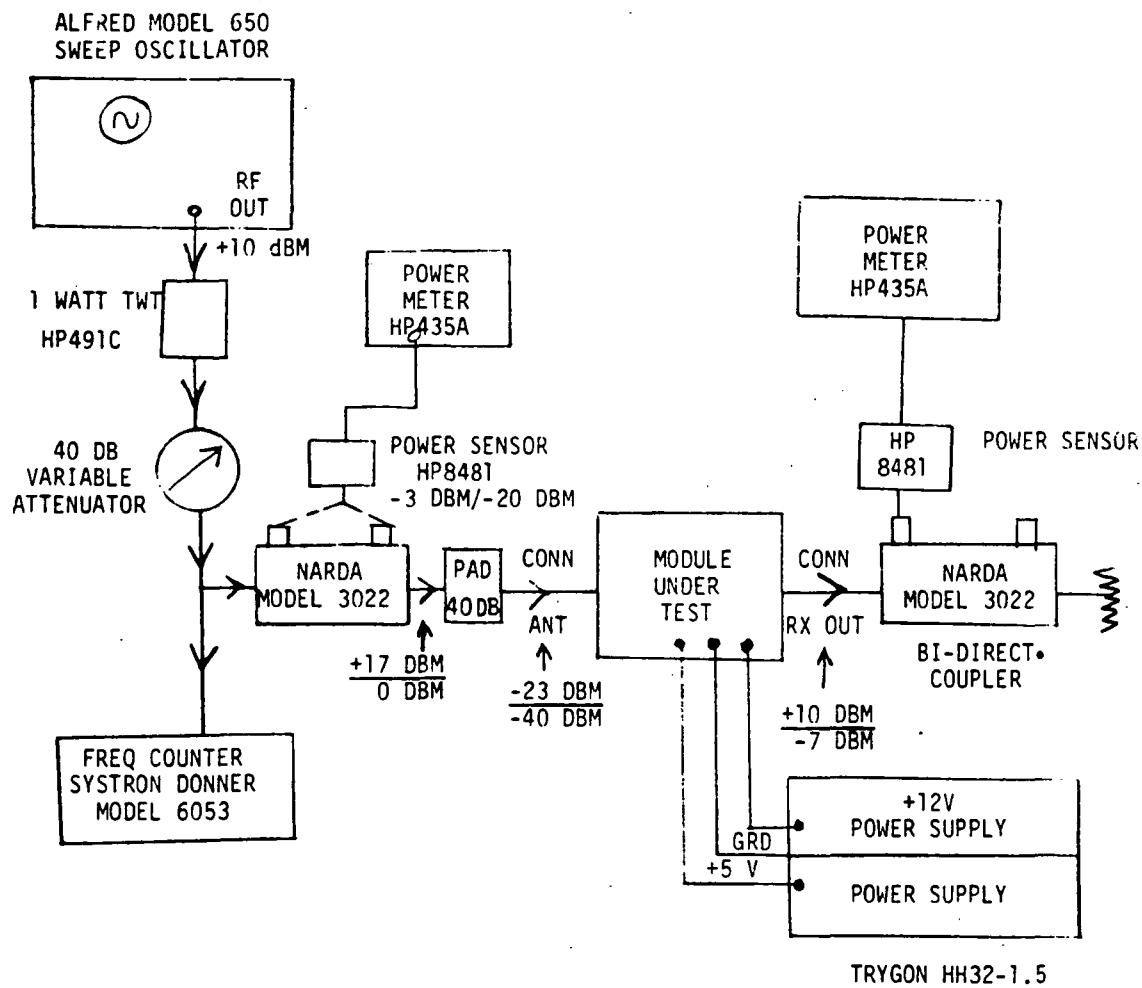
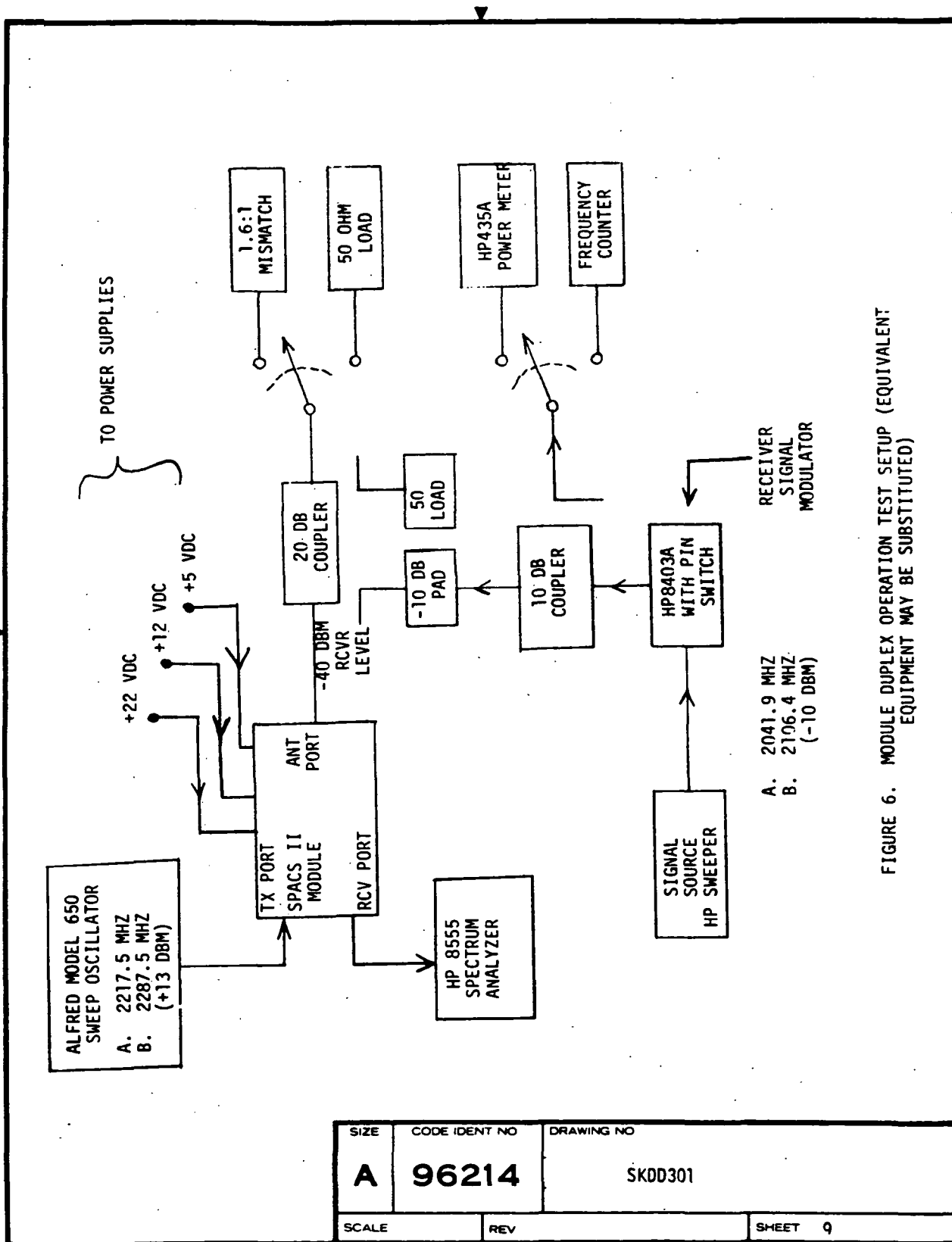


FIGURE 5. RECEIVER COMPRESSION (1 DB) POINT TEST SETUP
(EQUIVALENT EQUIPMENT MAY BE SUBSTITUTED)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 8

A-8



The module will also be evaluated in the fully duplexed mode with pulsed modulation on the receive carrier frequency such that a $\sin x/x$ frequency spectrum is established with 4.6 MHz between second nulls. As viewed on a spectrum analyzer log display, no visible receiver distortion should occur for the transmitter-on under duplex operation. Pictures of these modulated receiver signals will be taken and attached to data sheets (SKDD302), Table V. These pictures will be at both receive frequencies with transmitter on and off. The only discernable change between transmitter on and off should be a drop in amplitude at all frequencies due to some receiver compression. This will not affect receiver performance.

VII. MODULE L-BAND OPERATIONAL TEST

This test applies only to those modules with L-Band receive capability (center modules, SK446962-1). The L-Band portion of the module will be tested using a Hewlett-Packard ANA Model 8542A under small signal conditions. The measurement will be controlled by a nP software program AG303.

This measurement will use the same test setup as shown in Figure 1 with the exception of the HP8746 test unit for the HP8745 test unit. The device-under-test will be the L-Band receive portion of the SPACS II module. Input power level will be -20 dBm.

A summary of this data will be recorded in Table VI. The transmission loss should be less than 4 dB at 1775.5 and 1831.8 MHz. This corresponds to a noise temperature of less than 440°K. Noise temperature will not be measured since all losses are ohmic and no active devices are located in this path.

SIZE	CODE IDENT NO.	DRAWING NO.
A	96214	SKDD301
SCALE	REV	SHEET 10

A-10

APPENDIX

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD301	
SCALE	REV	SHEET	11

TI-7915C

A-11

APPENDIX

TRANSMIT/RECEIVE MICROELECTRONICS MODULE DESIGN SPECIFICATION

1.0 MODULE TECHNICAL REQUIREMENTS

1.1 Transmitter

1.1.1 Bandpass Characteristics

1.1.1.1 Center Frequency

The nominal center frequency shall be $f_T = 2252$ MHz.

1.1.1.2 Bandpass

± 55 MHz centered at f_T (1 dB - BW)

1.1.1.3 Bandshape

The bandshape shall be such that the output signal level described in paragraph 1.1.2.2.2 is achieved at each of the frequencies described in paragraph 1.1.2.1.1, and that the response ± 2304 KHz from either of the frequencies described in paragraph 1.1.2.1.1 varies less than 0.5 dB.

1.1.1.4 Response 100 MHz from Center of Bandpass

Attenuation at ± 100 MHz from f_T is more than 10 dB with respect to response at f_T .

1.1.1.5 Response 150 MHz from Center of Bandpass

Attenuation at ± 150 MHz from f_T is more than 20 dB with respect to response at f_T .

1.1.2 Signal Characteristics

1.1.2.1 Input Signal

1.1.2.1.1 Type

The input signal shall be a single angle modulated carrier operating at either one of two carrier frequencies, 2217.5 or 2287.5 MHz.

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 12

A-12

1.1.2.1.2 Modulation Width

The extent of the input signal spectrum shall be 2304 KHz from the carrier frequency to the second null of the spectrum.

1.1.2.1.3 Power Level

The input transmit signal at the input connector of each transceiver module shall be 13 dBm \pm 1 dB.

1.1.2.2 Output Signal

1.1.2.2.1 Characteristics

The output signal shall be a replica of the single carrier input signal within the bandwidth of Paragraph 1.1.1.2.

1.1.2.2.2 Transceiver Module Power Output

The output power from each module at either frequency of Paragraph 1.1.2.1.1 will be no less than 35 dBm when terminated in a nominal 50 Ω load having a VSWR no greater than 1.5:1.

1.2 Receiver

The specifications for the receiver portion of the system are limited to the transceiver modules inasmuch as the system tests which validate the receiver performance are not included in this scope of work.

1.2.1 Bandpass Characteristics

The receiver has two frequency bands: one in S-band nominally centered at 2074 MHz (f_{RS}) and one in L-band nominally centered at 1804 MHz (f_{RL}). Only the center module will have an L-band frequency lead. The bandpass centered about the above center frequencies will be the following:

1.2.1.1 S-band Bandpass

87 MHz centered at f_{RS} (0.5 dB - BW).

1.2.1.2 L-band Bandpass

62 MHz centered at f_{RL} (0.5 dB - BW)

1.2.1.3 S-band Bandshape

The bandshape shall be such that the gain (described in Paragraph 1.2.2.2 and noise temperature described in Paragraph 1.2.2.4 shall be achieved at each of the S-band frequencies described in Paragraph 1.2.2.1) varies less than 0.5 dB.

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD301	
SCALE		REV	SHEET 13

A-13

1.2.1.4 L-band Bandshape

The bandshape shall be such that the loss described in Paragraph 1.2.2.3 and the noise temperature described in Paragraph 1.2.2.5 shall be achieved at each of the L-band frequencies described in Paragraph 1.2.2.1.1 and the response ± 2304 KHz from either of the L-band frequencies described in Paragraph 1.2.1.1 varies less than 0.5 dB. Only the center module has L-band capability.

1.2.1.5 Attenuation at $f_{RS} \pm 100$ MHz from f_{RS} is no less than 15 dB with respect to carrier with 20 dB as a design goal.

1.2.1.6 Attenuation at $f_{RS} \pm 140$ MHz from f_{RS} is no less than 40 dB with respect to the carrier with 45 dB as a design goal.

1.2.1.7 Attenuation at $f_{RS} \pm 250$ MHz from f_{RS} is no less than 60 dB with respect to the carrier.

1.2.2 Signal Characteristics

1.2.2.1 Input Signal

The input signal shall be a single angle modulated signal operating at a frequency of 2041.9, 2106.4, 1775.5 or 1831.8 MHz. The bandwidth of the L-band signal is at most ± 2.304 MHz from the carrier frequency to the second null. The S-band signal bandwidth when receiving from the ground system will be at most 4.6 MHz between second nulls. The S-band signal bandwidth when receiving from the Tracking and Data Relay Satellite shall be 22 MHz.

1.2.2.2 S-Band Receive Electronic Gain

The electronic gain to all signals in the S-band signal bandpass of Paragraph 1.2.1.1 shall be greater than 25 dB. This gain is measured from the antenna port of a single transceiver module to the S-band output port up to an output signal level of 0 dBm.

1.2.2.3 L-Band Electronic Loss

The L-band electronic loss shall be less than 4 dB between the antenna connector of the central module to the L-band output port.

1.2.2.4 Noise Temperature (S-band)

The S-band transceiver module noise temperature referenced to the module antenna connector shall be less than 700°K with a design goal of 600°K over any 10 MHz in the bandpass described in Paragraph 1.2.1.1 when terminated into a 50 ohm load at the S-band output connector.

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 14

1.2.2.5 Noise Temperature (L-band)

The L-band noise temperature of the S-band antenna subsystem referenced to the center module antenna connector shall be less than 440°K over any 10 MHz in the bandpass described in Paragraph 1.2.1.2 when terminated into a 50 ohm load.

1.3 Suitable Module Temperature Range

To meet all module power, gain, noise figure and phase requirements, the maximum module case temperature range is 0°C to +45°C.

SIZE	CODE IDENT NO	DRAWING NO	
A	96014	SKDD301	
SCALE		REV	SHEET 15



APPENDIX B

B-1

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	81.7 Ref.	1.213	34.86	22.89	$I_{5V} = \underline{76}$
	45	44.4 37.3	1.131	34.82	22.86	
	90	-4.6 86.3	1.534	34.88	22.92	$I_{12V} = \underline{40}$
	135	-34.5 116.2	1.430	35.14	23.18	
	180	-106.3 188.0	1.145	34.89	22.92	$I_{22V} = \underline{925}$
	225	-137.8 219.5	1.104	35.03	23.07	
	270	171.5 270.2	1.147	35.23	23.26	
	315	135.7 303.0	1.057	35.12	23.16	
2257.5	0	-127.9 Ref.	1.678	35.99	24.01	$I_{5V} = \underline{76}$
	45	-166.9 39.0	2.052	35.54	23.57	
	90	144.1 82.2	1.459	35.76	23.78	$I_{12V} = \underline{41}$
	135	105.8 126.3	1.256	36.20	24.22	
	180	50.1 182.0	1.424	36.41	24.41	$I_{22V} = \underline{950}$
	225	17.1 215.0	1.324	36.13	24.15	
	270	-32.0 264.1	1.283	36.06	24.08	
	315	-82.9 315.0	1.679	35.97	24.00	
2287.5	0	84.8 Ref.	2.232	35.03	23.03	$I_{5V} = \underline{76}$
	45	51.7 33.1	2.405	34.58	22.58	
	90	-4.1 88.9	1.148	35.41	23.41	$I_{12V} = \underline{40}$
	135	-43.6 128.4	1.527	35.12	23.12	
	180	-99.0 183.8	1.821	35.45	23.45	$I_{22V} = \underline{740}$
	225	-132.0 216.8	1.913	34.98	22.98	
	270	171.2 273.5	1.434	35.51	23.51	
	315	137.4 307.4	1.789	35.01	23.01	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET
		2

VI-7015C

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	84.0 Ref.	1.427	34.81	21.83	I _{5V} = <u>76</u> I _{12V} = <u>40</u> I _{22V} = <u>945</u>
	45	48.1 35.9	1.121	34.69	21.72	
	90	-6.2 90.2	1.538	34.92	21.95	
	135	-36.0 120.0	1.542	35.11	21.14	
	180	-106.0 190.0	1.310	34.94	21.96	
	225	-138.3 222.3	1.124	35.08	22.11	
	270	168.4 295.6	1.228	35.28	22.31	
	315	137.3 306.7	1.121	35.11	22.13	
2257.5	0	-126.6 Ref.	1.520	36.00	23.01	I _{5V} = <u>76</u> I _{12V} = <u>41</u> I _{22V} = <u>930</u>
	45	-169.4 42.8	1.639	35.73	22.73	
	90	148.1 85.3	1.202	35.85	22.85	
	135	102.8 130.6	1.171	36.26	23.26	
	180	53.3 180.1	1.157	36.47	23.47	
	225	9.1 224.3	1.142	36.52	23.52	
	270	-33.1 266.5	1.152	36.19	23.20	
	315	-79.4 312.8	1.424	36.05	23.05	
2287.5	0	78.2 Ref.	1.874	35.70	22.71	I _{5V} = <u>76</u> I _{12V} = <u>40</u> I _{22V} = <u>840</u>
	45	47.8 30.4	1.909	35.32	22.33	
	90	-6.0 84.2	1.076	35.62	22.63	
	135	-48.0 126.2	1.318	35.69	22.70	
	180	-100.7 178.9	1.500	35.91	22.92	
	225	-134.5 212.7	1.565	35.72	22.73	
	270	168.0 270.2	1.201	35.92	22.93	
	315	129.6 308.6	1.535	35.87	22.88	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	55.4 Ref.	1.614	34.53	20.79	$I_{5V} = 76$ $I_{12V} = 40$ $I_{22V} = 970$
	45	50.7 34.7	1.310	34.82	20.75	
	90	-5.0 90.4	1.529	35.00	20.97	
	135	-34.9 120.3	1.646	35.22	21.19	
	180	-104.4 189.8	1.476	35.08	21.07	
	225	-139.0 224.4	1.255	35.80	21.26	
	270	169.7 275.7	1.340	35.42	21.39	
	315	139.0 307.4	1.273	35.17	21.14	
2257.5	0	-125.9 Ref.	1.574	35.99	21.96	$I_{5V} = 76$ $I_{12V} = 41$ $I_{22V} = 960$
	45	-167.8 41.9	1.511	35.87	21.85	
	90	147.1 87.0	1.089	35.92	21.89	
	135	103.5 130.6	1.322	36.30	22.28	
	180	53.2 180.9	1.046	36.55	22.52	
	225	8.9 225.2	1.176	36.66	22.63	
	270	-36.7 270.8	1.168	36.39	22.86	
	315	-80.2 314.3	1.395	36.12	22.07	
2287.5	0	77.2 Ref.	1.637	36.0	22.03	$I_{5V} = 76$ $I_{12V} = 40$ $I_{22V} = 900$
	45	45.7 31.5	1.672	35.72	21.75	
	90	-9.9 87.1	1.186	35.81	21.85	
	135	-44.8 127.0	1.263	36.03	22.06	
	180	-103.2 180.4	1.340	36.28	22.32	
	225	-139.6 211.8	1.400	36.09	22.12	
	270	172.3 264.9	1.202	36.09	22.13	
	315	128.1 309.1	1.281	36.16	22.20	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-60.0 Ref.	2.383	35.18	14.8	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	-102.1 42.1	2.506	35.16	14.9	
	90	-149.8 87.8	2.514	34.30	15.0	
	135	175.2 124.8	2.225	33.50	14.77	
	180	111.9 188.1	2.212	34.61	14.28	
	225	73.5 226.5	2.047	34.57	14.91	
	270	26.7 273.3	2.121	34.53	14.88	
	315	-12.1 312.1	1.979	34.39	14.80	
2041.9	0	-118.9 Ref.	2.033	34.49	13.67	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	-161.1 42.2	2.206	34.32	13.84	
	90	152.7 88.4	2.332	33.77	13.10	
	135	116.7 124.4	2.366	33.85	13.67	
	180	55.4 185.7	2.148	34.22	13.49	
	225	14.5 226.6	2.157	34.52	13.69	
	270	-32.3 273.4	2.169	34.55	13.38	
	315	-70.8 311.9	2.131	34.68	13.88	
2052.9	0	-173.0 Ref.	2.070	33.26	12.20	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	144.1 42.9	2.267	33.61	11.91	
	90	100.8 86.2	2.471	33.40	12.08	
	135	62.5 124.5	2.827	33.54	13.24	
	180	1.9 185.1	2.43	33.66	11.91	
	225	-39.8 226.8	2.51	34.28	12.28	
	270	-85.3 272.3	2.51	34.00	12.13	
	315	-125.7 312.7	2.58	34.08	13.01	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET
		5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	93.1 Ref.	1.667	33.03	12.12	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	48.9 44.2	1.681	33.40	12.87	
	90	2.9 90.2	1.805	33.31	12.77	
	135	-40.7 133.8	2.097	33.36	12.56	
	180	-91.5 184.6	1.920	33.59	12.21	
	225	-136.6 229.7	2.039	33.57	12.78	
	270	177.3 275.8	1.999	33.17	12.50	
	315	132.8 320.3	2.059	33.24	11.92	
2095.4	0	-4.2 Ref.	2.470	33.55	13.49	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	-51.6 47.4	2.185	33.75	13.24	
	90	-96.8 92.6	2.042	33.39	13.35	
	135	-138.4 134.2	2.108	32.51	13.096	
	180	170.5 185.3	2.360	33.35	12.970	
	225	125.1 230.7	2.334	33.17	12.26	
	270	81.3 274.5	2.312	33.14	12.91	
	315	38.5 317.3	2.361	32.69	12.55	
2106.4	0	-57.4 Ref.	2.324	34.54	16.434	I _{5V} = <u>75</u> I _{12V} = <u>40</u>
	45	-104.0 46.6	1.899	34.17	16.144	
	90	-149.7 92.3	1.722	33.40	15.98	
	135	169.8 132.8	1.722	32.88	15.10	
	180	119.1 183.5	2.023	34.03	15.37	
	225	76.6 226.0	1.969	33.56	15.41	
	270	30.2 272.4	1.965	33.51	15.33	
	315	-11.2 313.8	2.008	33.41	15.0	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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INPUT POWER LEVEL = -40 DBM

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	4.5	527.3	+8.7	-25.2	33.9
2041.9	4.6	546.4	+9.2	-24.0	33.2
2052.9	4.6	546.4	+9.6	-22.7	32.5
2074.15	4.7	565.9	+10.0	-21.4	31.4
2095.4	4.1	455.4	+10.2	-21.7	31.9
2106.4	4.1	455.4	+10.3	-22.2	32.5
2117.4	4.2	472.8	+10.5	-23.1	33.6

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-5.5	--	—	OFF/2041.9	1.6:1
-40	-7.5	> +35	+9.0	2217.5/2041.9	1.6:1
-40	-5.0	--	—	OFF/2106.4	1.6:1
-40	-5.5	> +35	-4.5	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		8

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

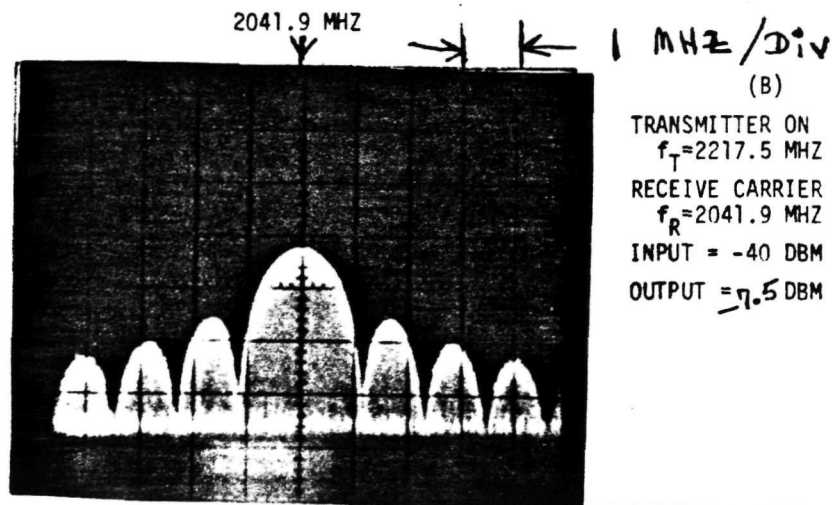
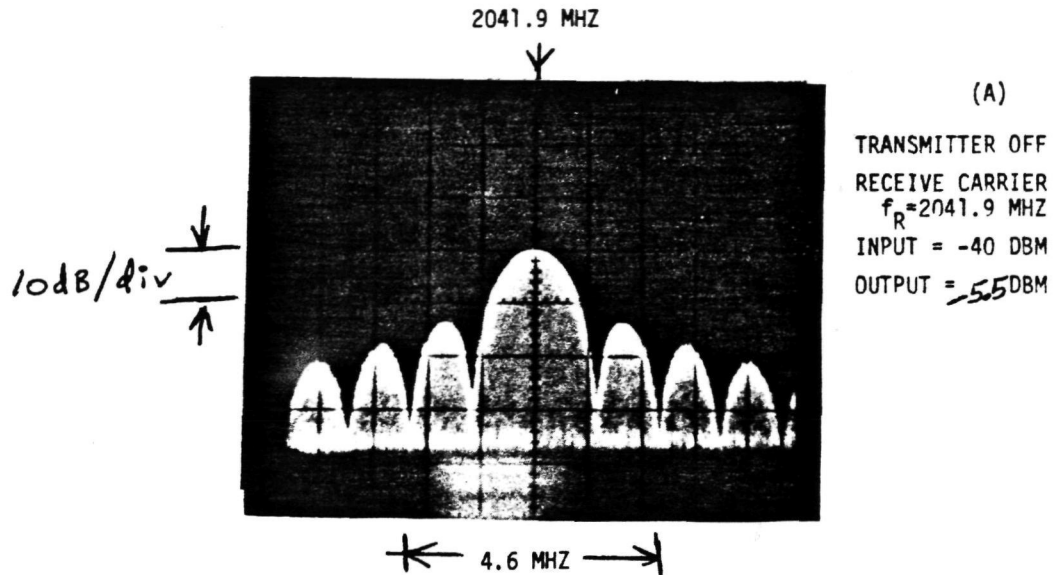
		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2390 MHz >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 1

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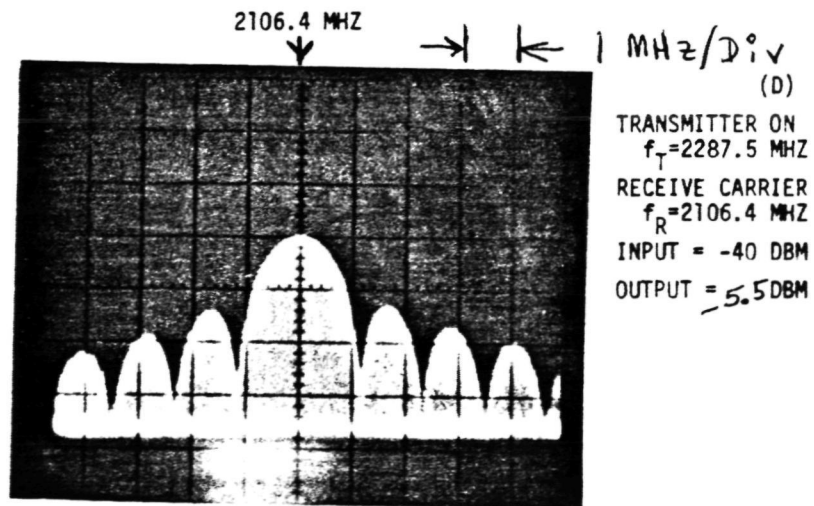
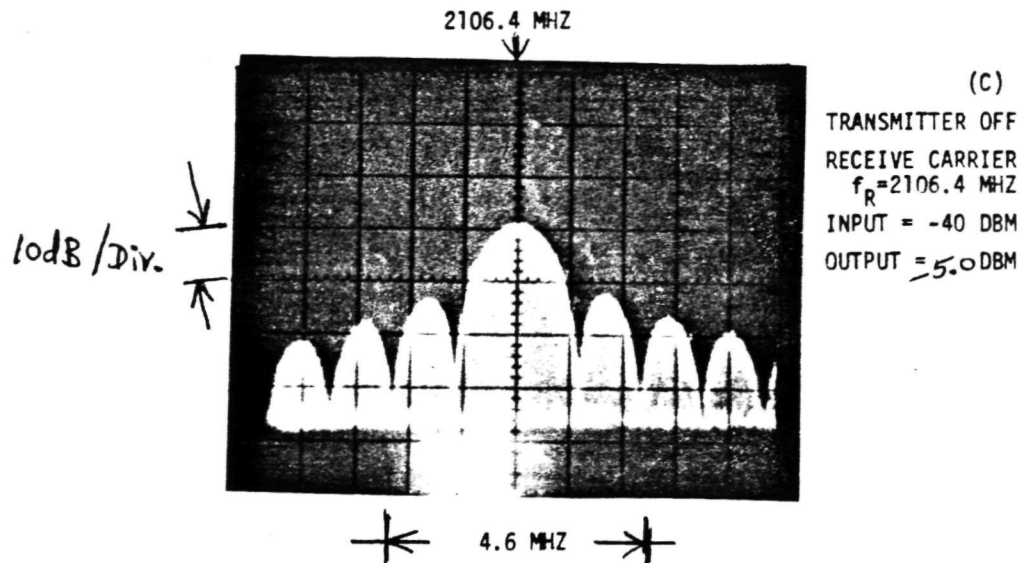
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TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 10 1

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET
		11

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600 1775.5 1803.65 1831.8 2000	N.A. ↓	N.A. ↓	N.A. ↓

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	73.8 REF	1.494	35.63	23.61	I _{5V} = <u>101</u>
	45	18.8	1.897	35.52	23.5	I _{12V} = <u>44</u>
	90	-24.0	1.561	35.65	23.63	
	135	-84.3	1.325	35.46	23.44	I _{22V} = <u>1120</u>
	180	-125.6	1.392	35.42	23.40	
	225	-172.5	1.708	35.57	23.55	
	270	144.1	1.698	35.62	23.60	
	315	99.1	1.373	35.49	23.47	
2257.5	0	-115.1 REF	2.266	35.68	23.70	I _{5V} = <u>101</u>
	45	-152.5	1.854	35.94	23.90	I _{12V} = <u>44</u>
	90	151.1	1.790	35.98	24.01	
	135	105.5	1.414	35.63	23.65	I _{22V} = <u>760</u>
	180	52.9	1.787	35.49	23.51	
	225	16.4	1.861	35.93	23.95	
	270	-35.9	2.344	35.90	23.93	
	315	-82.1	1.708	35.46	23.48	
2287.5	0	138.2 REF	2.563	34.75	22.75	I _{5V} = <u>101</u>
	45	76.5	1.437	35.17	23.17	I _{12V} = <u>44</u>
	90	25.8	1.934	34.80	22.80	
	135	-20.7	1.600	34.90	22.90	I _{22V} = <u>610</u>
	180	-65.7	1.970	34.70	22.70	
	225	-108.2	1.756	35.15	23.15	
	270	-156.8	2.103	34.82	22.82	
	315	155.9	1.252	34.67	22.68	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET
		2 3

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	72.6 REF	1.341	35.58	22.57	I _{5V} = <u>101</u> I _{12V} = <u>44</u> I _{22V} = <u>1130</u>
	45	17.4 55.2	1.753	35.47	22.47	
	90	-20.8 97.4	1.484	35.58	22.57	
	135	-85.3 157.9	1.262	35.41	22.40	
	180	-125.6 198.2	1.221	35.35	22.34	
	225	-173.6 246.2	1.566	35.53	22.52	
	270	145.2 287.4	1.507	35.57	22.56	
	315	99.9 332.7	1.257	35.45	22.44	
2257.5	0	-115.8 REF	1.942	35.66	22.66	I _{5V} = <u>101</u> I _{12V} = <u>44</u> I _{22V} = <u>1020</u>
	45	-159.0 43.2	1.558	35.80	22.80	
	90	149.9 94.3	1.549	35.85	22.85	
	135	101.7 142.5	1.219	35.52	22.52	
	180	52.7 191.5	1.548	35.45	22.45	
	225	11.7 232.5	1.592	35.82	22.83	
	270	-36.7 280.9	1.958	35.78	22.78	
	315	-82.4 326.6	1.517	35.38	22.39	
2287.5	0	125.9 REF	2.186	35.03	22.04	I _{5V} = <u>101</u> I _{12V} = <u>44</u> I _{22V} = <u>710</u>
	45	73.7 52.2	1.328	35.16	22.17	
	90	23.9 102.0	1.790	34.96	21.97	
	135	-22.1 148.0	1.480	34.98	21.99	
	180	-70.0 195.9	1.776	34.95	21.96	
	225	-112.7 238.6	1.616	35.21	22.22	
	270	-158.2 286.1	1.913	34.97	21.98	
	315	154.8 331.1	2.059	34.85	21.86	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		3

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA	
2217.5	0	72.7	REF	1.183	35.29	21.27	I _{5V}	= <u>101</u>
	45	17.8	55.9	1.614	35.09	21.48		
	90	-23.4	97.1	1.416	35.00	21.58		
	135	-83.9	157.6	1.212	35.43	21.41	I _{12V}	= <u>44</u>
	180	-125.2	148.9	1.046	35.06	21.25		
	225	-172.2	245.9	1.405	35.53	21.52		
	270	147.2	250.5	1.350	35.58	21.56	I _{22V}	= <u>1150</u>
	315	102.0	221.7	1.192	35.05	21.46		
2257.5	0	-115.4	REF	1.748	35.65	21.65	I _{5V}	= <u>101</u>
	45	-16.1	45.7	1.241	35.80	21.79		
	90	150.2	95.4	1.420	35.78	21.77		
	135	100.9	143.7	1.097	35.5	21.49	I _{12V}	= <u>44</u>
	180	53.2	191.4	1.521	35.46	21.46		
	225	8.9	235.7	1.411	35.75	21.74		
	270	-36.5	281.1	1.737	35.70	21.69	I _{22V}	= <u>1040</u>
	315	-81.8	326.4	1.436	35.37	21.26		
2287.5	0	124.2	REF	1.949	35.19	21.17	I _{5V}	= <u>101</u>
	45	71.6	52.6	1.311	35.21	21.19		
	90	23.6	100.6	1.744	35.08	21.06		
	135	-23.1	147.3	1.456	35.10	21.08	I _{12V}	= <u>44</u>
	180	-70.6	194.8	1.708	35.10	21.08		
	225	-114.0	238.2	1.610	35.25	21.23		
	270	-158.7	282.9	1.828	35.08	21.06	I _{22V}	= <u>810</u>
	315	154.7	329.5	1.962	34.94	20.92		

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		4 3

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

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FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY * CURRENTS MA
2030.9	0	-75.8 REF	1.139	32.62	18.511	I _{5V} = <u>99</u> I _{12V} = <u>45</u>
	45	-113.0 37.2	1.234	31.71	18.659	
	90	-151.6 75.8	1.351	31.40	18.211	
	135	153.4 120.8	1.356	31.77	17.537	
	180	110.1 174.1	1.354	31.85	17.728	
	225	71.3 212.9	1.321	31.43	18.956	
	270	31.9 252.3	1.314	31.28	19.592	
	315	-12.8 297.0	1.255	32.05	20.152	
2041.9	0	-149.1 REF	1.258	33.05	15.793	I _{5V} = <u>99</u> I _{12V} = <u>45</u>
	45	173.1 37.8	1.257	32.21	15.248	
	90	136.3 74.6	1.129	32.42	15.304	
	135	84.0 126.9	1.045	33.09	15.927	
	180	39.9 171.0	1.107	33.20	16.950	
	225	-3.7 214.6	1.140	32.69	16.470	
	270	-45.7 256.6	1.189	32.95	16.398	
	315	-92.6 303.5	1.297	33.68	16.808	
2052.9	0	148.4 REF	2.241	32.82	12.891	I _{5V} = <u>99</u> I _{12V} = <u>45</u>
	45	112.7 35.7	2.361	32.14	13.205	
	90	75.7 72.7	2.193	32.65	14.513	
	135	20.9 127.5	1.929	33.15	14.303	
	180	-27.2 175.6	1.746	33.66	14.266	
	225	-69.0 217.4	1.839	33.00	14.163	
	270	-110.6 259.0	1.805	32.99	14.537	
	315	-159.1 307.5	2.046	33.17	13.655	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5 3

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	REF	2.072	31.52	12.162	$I_{5V} = 99$ $I_{12V} = 45$
	45	107	2.614	31.25	12.195	
	90	-22.1	2.515	31.22	12.254	
	135	-84.7	2.791	32.21	13.225	
	180	-134.4	2.427	32.51	12.422	
	225	-172.2	2.569	31.34	11.964	
	270	100.8	2.011	31.52	12.301	
	315	101.1	2.078	31.54	12.551	
2095.4	0	REF	1.207	32.12	12.204	$I_{5V} = 99$ $I_{12V} = 45$
	45	-98.0	1.823	31.91	12.067	
	90	-143.9	1.973	32.10	12.111	
	135	172.7	1.612	32.29	12.265	
	180	127.3	1.647	31.69	12.060	
	225	28.0	1.010	31.15	12.080	
	270	42.8	1.390	31.60	12.327	
	315	-1.2	1.238	32.07	12.057	
2106.4	0	REF	1.236	32.09	12.495	$I_{5V} = 99$ $I_{12V} = 45$
	45	-151.4	1.577	31.62	14.259	
	90	106.5	1.829	31.51	14.196	
	135	120.1	1.595	31.63	14.318	
	180	77.1	1.553	31.35	13.791	
	225	36.6	1.441	31.69	14.114	
	270	-7.3	1.421	31.81	14.801	
	315	-55.2	1.204	32.38	15.229	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		6 3

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-170.7	REF	1.414	31.96	15.875	I _{5V} = <u>99</u> I _{12V} = <u>45</u>
	45	152.4	36.9	1.375	31.36	16.059	
	90	110.3	79.0	1.227	31.54	16.037	
	135	67.4	121.9	1.059	32.22	15.836	
	180	22.5	193.2	1.111	32.25	16.727	
	225	-19.3	208.6	1.116	32.01	16.852	
	270	-65.9	255.2	1.116	32.29	16.432	
	315	-115.6	306.9	1.339	32.90	16.068	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 7

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POOR QUALITY

TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	6.7	1066.4	+8.55	-20.7	29.0
2041.9	6.1	891.4	+7.52	-21.5	29.0
2052.9	6.0	864.5	+4.28	-23.52	27.8
2074.15	6.7	1066.4	+0.13	-23.48	23.61
2095.4	5.7	787.5	-0.45	-23.4	20.45
2106.4	5.3	692.7	+1.1	-20.6	21.16
2117.4	5.2	670.3	+2.37	-17.95	17.62

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-10.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-8.0	--	—	OFF/2106.4	1.6:1
-40	-9.0	> +35	-4.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		8 3

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TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

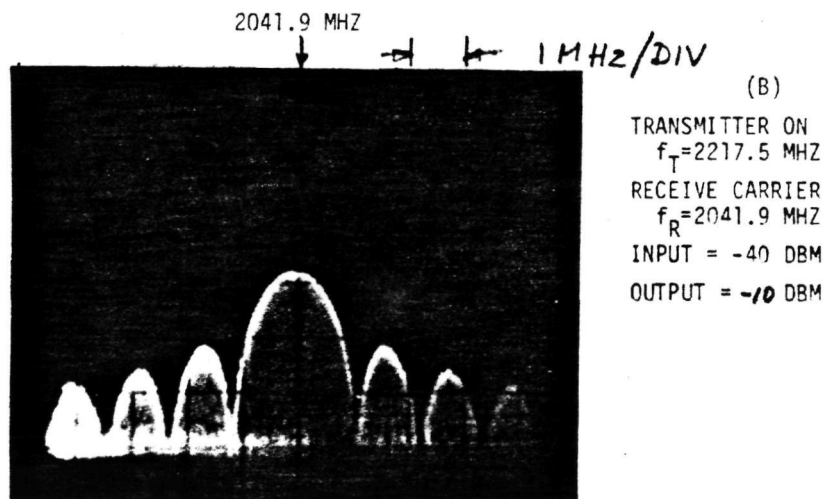
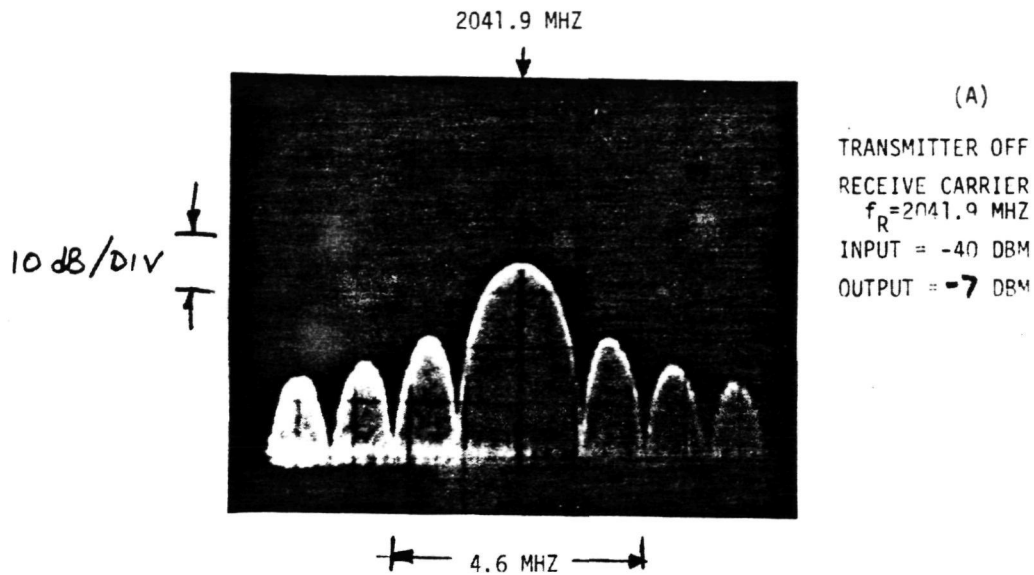
		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	<u>2390 MHz</u> >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 3

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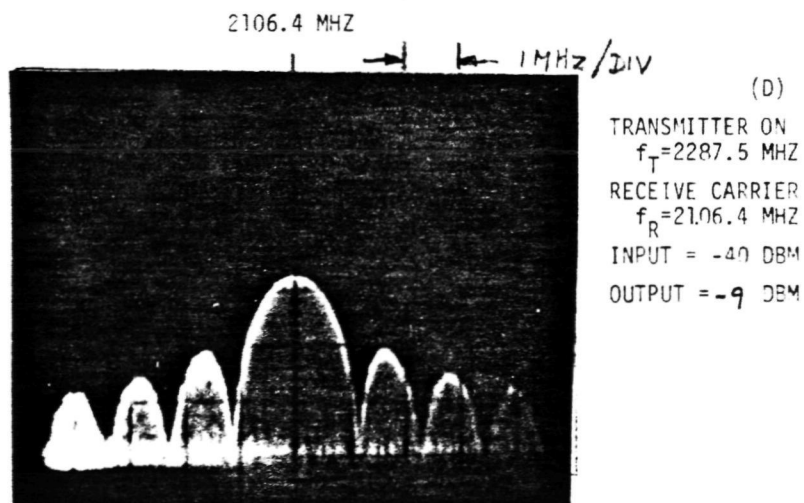
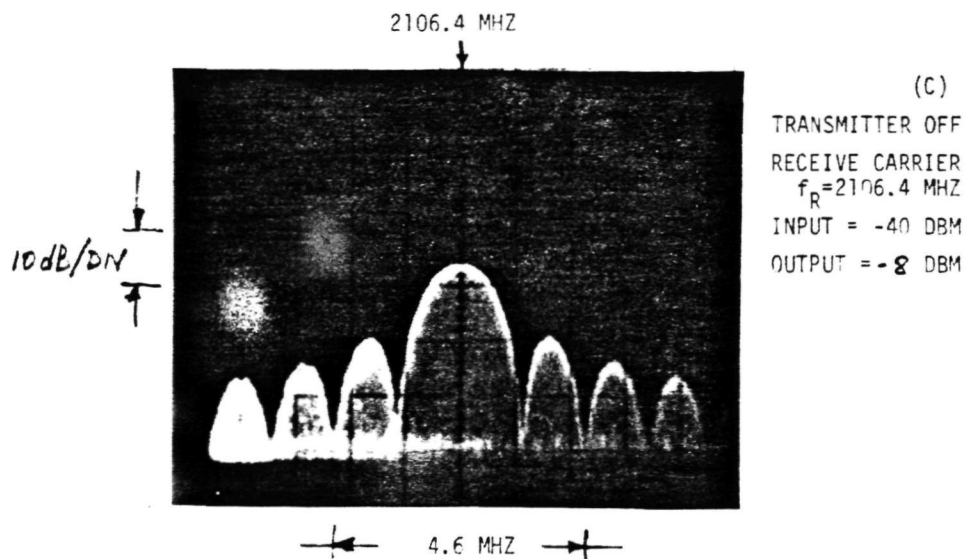
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TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 10
		3

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO		
A	96214	SKDD302	B-23	
SCALE	REV	SHEET	11	3

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N. A.	N. A.	N. A.
1775.5			
1803.65			
1831.8			
2000	7	↓	↓

SIZE A	CODE IDENT NO 96214	DRAWING NO SKDD302	<i>B-24</i>
SCALE	REV	SHEET 12	

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.7 Ref.	1.235	35.22	23.21	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>950</u>
	45	23.7 59.0	1.815	35.07	23.06	
	90	-8.5 91.2	1.550	34.58	22.58	
	135	-80.0 162.7	1.405	34.64	22.64	
	180	-110.8 193.5	1.178	33.17	21.16	
	225	-170.5 253.2	1.587	34.43	22.92	
	270	160.1 282.6	1.682	34.71	22.70	
	315	109.2 333.5	1.476	34.71	22.70	
2257.5	0	-132.2 Ref.	1.914	35.30	23.33	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>810</u>
	45	-156.8 24.6	2.363	34.97	23.00	
	90	145.1 82.7	1.669	35.15	23.16	
	135	97.3 130.5	1.684	35.32	23.33	
	180	48.3 179.5	1.268	35.13	23.14	
	225	9.2 218.6	1.945	34.97	22.78	
	270	-39.4 267.2	1.700	35.05	23.06	
	315	-86.3 314.1	1.421	35.03	23.04	
2287.5	0	101.6 Ref.	2.316	33.57	21.57	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>590</u>
	45	54.0 47.6	1.525	34.44	22.44	
	90	6.6 95.0	1.323	34.13	22.12	
	135	-44.7 146.3	1.418	34.38	22.37	
	180	-90.3 191.9	1.609	34.15	22.14	
	225	-130.8 232.4	1.477	34.56	22.55	
	270	-175.4 277.0	1.527	34.04	22.03	
	315	133.7 327.9	1.799	34.17	22.16	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	62.5 Ref.	1.174	35.33	22.32	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>900</u>
	45	10.3 52.2	1.804	35.20	22.19	
	90	-22.1 84.6	1.795	34.80	21.80	
	135	-12.5 155.0	1.432	34.60	21.60	
	180	-126.6 189.1	1.164	34.87	21.87	
	225	179.3 243.2	1.499	34.81	21.82	
	270	146.3 276.2	1.599	34.73	21.73	
	315	97.4 325.1	1.441	34.76	21.76	
2257.5	0	-133.6 Ref.	1.669	35.36	22.35	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>930</u>
	45	-167.8 34.2	2.065	35.32	22.31	
	90	142.0 84.4	1.397	35.15	22.14	
	135	92.1 134.3	1.426	35.28	22.28	
	180	47.2 179.2	1.227	35.32	22.31	
	225	3.0 223.4	1.650	35.04	22.03	
	270	-41.6 268.0	1.446	35.10	22.09	
	315	-88.4 314.8	1.230	35.07	22.06	
2287.5	0	93.5 Ref.	2.122	34.20	21.23	I _{5V} = <u>95</u> I _{12V} = <u>44</u> I _{22V} = <u>660</u>
	45	48.7 44.8	1.317	34.71	21.75	
	90	2.6 90.9	1.258	34.40	21.40	
	135	-47.4 140.9	1.257	34.55	21.55	
	180	-93.0 186.5	1.491	34.60	21.60	
	225	-134.5 228.0	1.304	34.77	21.77	
	270	-179.0 272.5	1.426	34.43	21.44	
	315	131.5 322.0	1.680	34.50	21.51	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 4

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta \phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	55.4 Ref.	1.175	35.23	21.21	$I_{5V} = \underline{95}$ $I_{12V} = \underline{44}$ $I_{22V} = \underline{990}$
	45	1.8 53.6	1.704	35.12	21.10	
	90	-30.6 86.0	1.715	34.76	20.75	
	135	-97.1 152.5	1.473	34.59	20.58	
	180	-133.8 189.2	1.225	24.84	20.82	
	225	175.8 239.6	1.366	34.74	20.72	
	270	141.5 273.9	1.528	34.67	20.76	
	315	92.9 322.5	1.457	34.73	20.71	
2257.5	0	-133.6 Ref.	1.552	35.40	21.35	$I_{5V} = \underline{95}$ $I_{12V} = \underline{44}$ $I_{22V} = \underline{765}$
	45	-173.5 37.9	1.730	35.45	21.40	
	90	140.6 85.8	1.194	35.17	21.14	
	135	90.1 136.3	1.231	35.29	21.26	
	180	47.1 179.3	1.324	35.33	21.30	
	225	0.5 225.8	1.384	35.11	21.00	
	270	-42.2 268.6	1.312	35.54	21.06	
	315	-89.0 315.4	1.164	35.02	20.99	
2287.5	0	89.4 Ref.	1.887	34.64	20.62	$I_{5V} = \underline{95}$ $I_{12V} = \underline{44}$ $I_{22V} = \underline{720}$
	45	44.5 44.9	1.142	34.76	20.94	
	90	0.8 88.6	1.280	34.62	20.61	
	135	-48.7 138.1	1.247	34.73	20.72	
	180	-93.8 183.2	1.456	31.87	20.86	
	225	-136.6 226.0	1.237	34.93	20.91	
	270	179.6 269.8	1.427	34.64	20.62	
	315	130.6 318.8	1.654	34.70	20.68	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-57.3 Ref.	3.505	29.99	13.034	I _{5V} = <u>93</u> I _{12V} = <u>44</u>
	45	-123.9 66.6	3.087	26.34	11.415	
	90	-167.8 110.5	2.577	26.64	11.083	
	135	179.3 123.4	2.719	28.76	11.320	
	180	140.4 162.3	2.658	29.61	12.747	
	225	79.7 223.0	2.744	27.56	12.370	
	270	37.4 265.3	2.871	28.09	12.441	
	315	-5.0 307.7	3.385	29.38	12.011	
2041.9	0	-108.9 Ref.	2.846	30.67	13.583	I _{5V} = <u>93</u> I _{12V} = <u>44</u>
	45	-169.1 60.2	2.798	27.27	12.081	
	90	148.3 102.8	2.280	27.64	12.413	
	135	134.5 116.6	2.711	30.28	13.875	
	180	89.9 161.2	2.398	30.93	15.458	
	225	30.7 220.4	2.467	28.84	13.311	
	270	-11.9 263.0	2.376	29.35	13.329	
	315	-52.5 303.6	3.129	30.44	13.891	
2052.9	0	-162.7 Ref.	2.118	31.33	13.355	I _{5V} = <u>93</u> I _{12V} = <u>44</u>
	45	143.1 54.2	2.410	28.31	13.805	
	90	99.2 98.1	2.027	28.74	14.310	
	135	79.6 117.7	2.680	32.01	16.409	
	180	28.7 168.6	2.009	32.25	15.347	
	225	-22.0 219.3	2.027	30.05	14.288	
	270	-64.7 262.0	1.763	29.96	13.757	
	315	-107.5 304.8	2.486	31.45	14.209	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	88.0 Ref.	1.353	31.03	13.063	I _{5V} = <u>93</u> I _{12V} = <u>71</u>
	45	29.5 58.5	1.344	29.24	13.384	
	90	-15.4 103.4	1.606	30.14	14.245	
	135	-50.8 138.8	1.607	32.23	13.640	
	180	-91.1 179.9	1.641	31.02	12.470	
	225	-133.6 221.6	1.419	29.65	11.941	
	270	-170.8 258.8	1.472	30.02	12.343	
	315	139.7 308.3	1.211	31.56	13.735	
2095.4	0	-10.6 Ref.	2.367	29.57	13.008	I _{5V} = <u>93</u> I _{12V} = <u>44</u>
	45	-71.2 60.6	1.953	26.79	11.622	
	90	-118.8 108.2	2.369	27.87	11.510	
	135	-148.0 137.4	1.953	28.66	11.075	
	180	-175.9 173.5	2.537	28.60	12.003	
	225	-136.0 212.4	2.318	27.24	11.625	
	270	-93.5 255.9	2.584	28.62	11.744	
	315	-39.3 310.1	2.090	29.37	11.740	
2106.4	0	-62.1 Ref.	2.039	30.03	15.490	I _{5V} = <u>73</u> I _{12V} = <u>44</u>
	45	-117.3 55.2	1.653	26.91	13.752	
	90	-164.4 102.1	1.933	27.82	14.599	
	135	-168.2 129.7	1.639	28.50	14.219	
	180	-128.4 169.5	2.272	28.97	15.120	
	225	-90.0 207.9	2.069	27.78	13.705	
	270	-46.9 251.0	2.721	29.51	15.219	
	315	-7.2 305.1	1.927	29.40	14.639	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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INPUT POWER LEVEL = -40 DBM

[illegible]

TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	6.0	865	+2.15	-29.64	31.79
2041.9	6.2	919	+1.11	-31.67	32.78
2052.9	6.2	919	+1.07	-34.69	35.76
2074.15	5.2	671	+0.97	-28.53	29.50
2095.4	5.0	627	+0.87	-28.75	29.62
2106.4	5.1	648	+1.84	-29.64	31.48
2117.4	5.2	671	+0.83	-32.16	32.99

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-9.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-7.5	--	—	OFF/2106.4	1.6:1
-40	-8.0	> +35	-8.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

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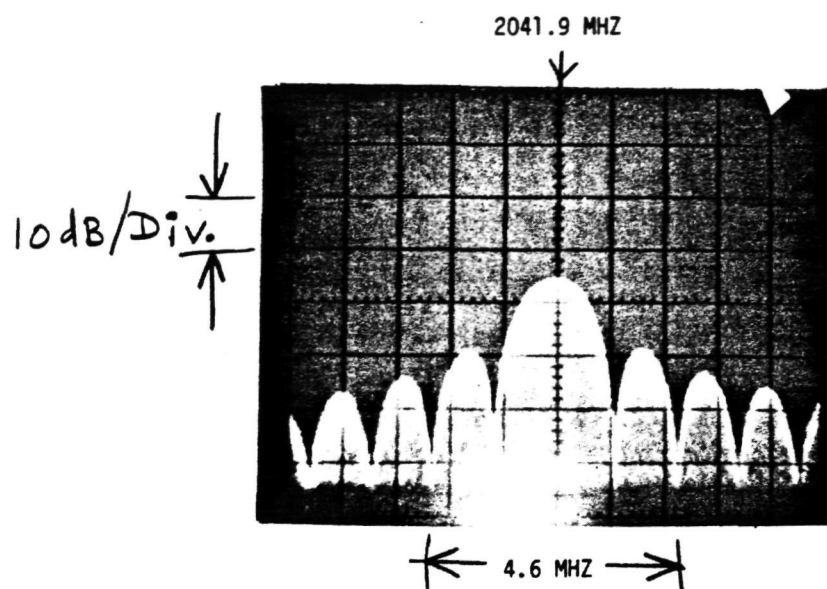
TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR	1.05:1	> 30	> 40	> 40	—
2217.5/2041.9					
2217.5/2041.9	1.6:1	> 30	2390 MHz > 20	> 40	—
2287.5/2106.4	1.05:1	> 40	> 40	> 40	—
2287.5/2106.4	1.6:1	> 30	> 40	> 40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 4

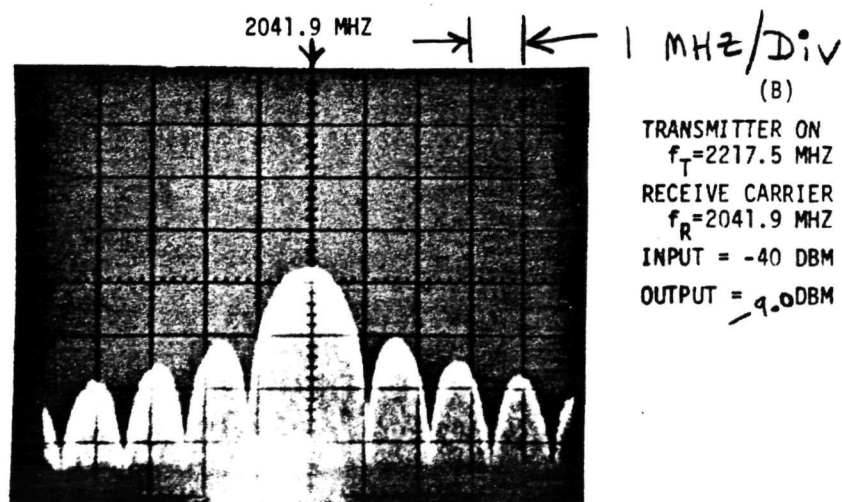
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TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



(A)

TRANSMITTER OFF
RECEIVE CARRIER
 $f_R = 2041.9$ MHZ
INPUT = -40 DBM
OUTPUT = -7.0 DBM

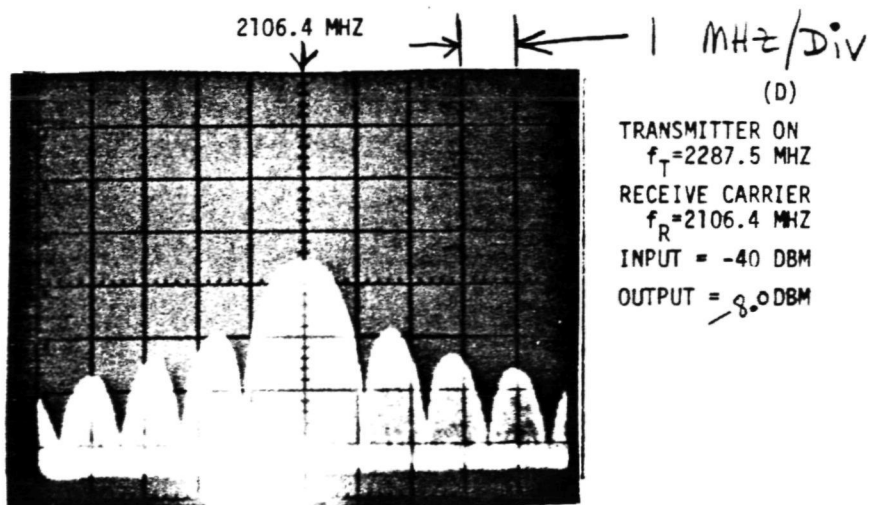
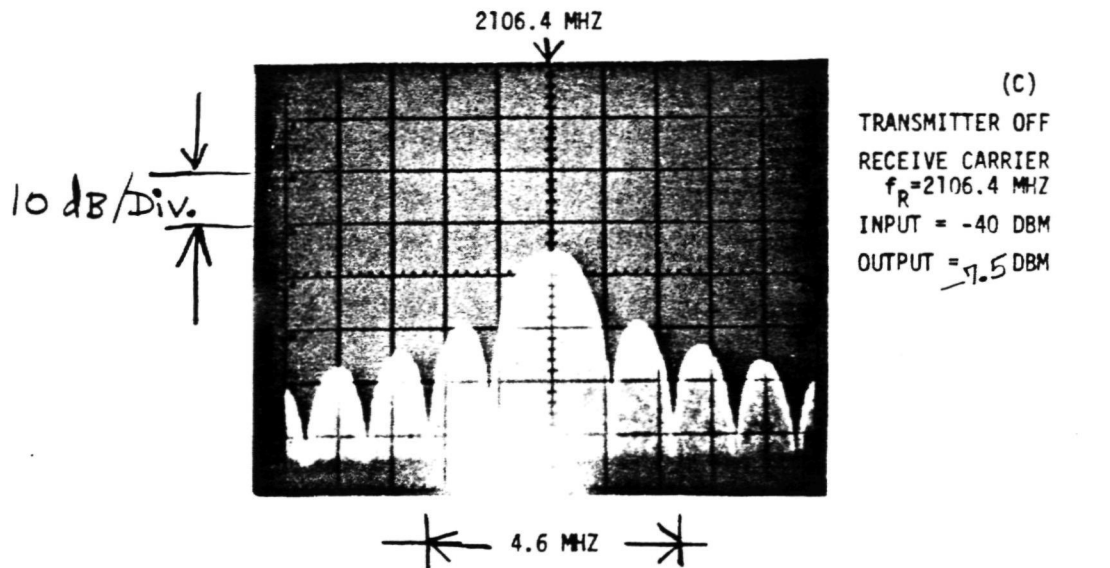


(B)

TRANSMITTER ON
 $f_T = 2217.5$ MHZ
RECEIVE CARRIER
 $f_R = 2041.9$ MHZ
INPUT = -40 DBM
OUTPUT = -9.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		10

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 11

B-3.5

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600 1775.5 1803.65 1831.8 2000	N.A. ↓	N.A. ↓	N.A. ↓

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	64.6 Ref.	1.404	35.18	23.19	$I_{5V} = 99$ $I_{12V} = 34$ $I_{22V} = 960$
	45	20.6 44.0	1.348	35.19	23.20	
	90	-36.3 100.9	1.579	35.29	23.3	
	135	-71.7 136.3	1.409	35.18	23.19	
	180	-134.5 199.1	1.326	35.17	23.18	
	225	-171.1 235.7	1.142	35.23	23.25	
	270	137.2 287.4	1.363	35.25	23.26	
	315	100.7 323.9	1.317	35.17	23.19	
2257.5	0	-125.0 Ref.	1.221	35.09	23.09	$I_{5V} = 99$ $I_{12V} = 34$ $I_{22V} = 830$
	45	-170.4 45.4	1.373	35.15	23.16	
	90	144.9 90.1	1.123	35.08	23.08	
	135	78.7 136.3	1.350	34.95	22.95	
	180	47.2 187.8	1.109	35.08	23.08	
	225	1.4 233.6	1.254	35.24	23.24	
	270	-45.0 280.0	1.209	35.06	23.06	
	315	-90.3 325.3	1.562	35.01	23.01	
2287.5	0	109.8 Ref.	1.453	33.8	21.8	$I_{5V} = 99$ $I_{12V} = 34$ $I_{22V} = 570$
	45	65.1 44.7	1.493	33.9	21.9	
	90	13.0 96.8	1.204	34.11	22.12	
	135	-31.0 140.8	1.497	33.7	21.72	
	180	-82.2 192.0	1.073	34.02	22.03	
	225	-125.1 234.9	1.318	33.95	21.96	
	270	-171.9 281.7	1.320	34.03	22.04	
	315	146.3 323.5	1.495	33.71	21.72	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET
		2

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	65.3 Ref.	1.459	35.15	22.15	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{960}$
	45	21.6 43.7	1.335	35.13	22.13	
	90	-35.5 100.8	1.581	35.25	22.25	
	135	-70.1 135.4	1.450	35.14	22.14	
	180	-132.4 198.7	1.426	35.10	22.10	
	225	-170.5 235.8	1.279	35.18	22.18	
	270	137.9 287.4	1.391	35.22	22.22	
	315	102.0 323.3	1.298	35.13	22.13	
2257.5	0	-123.9 Ref.	1.157	35.12	22.16	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{840}$
	45	-169.1 45.2	1.208	35.21	22.24	
	90	145.2 90.9	1.015	35.09	22.12	
	135	100.8 135.3	1.279	34.92	21.96	
	180	48.1 188.0	1.190	35.07	22.11	
	225	2.6 233.5	1.256	35.31	22.35	
	270	-44.3 280.4	1.220	35.08	22.11	
	315	-88.1 324.2	1.436	34.97	22.01	
2287.5	0	108.8 Ref.	1.354	34.03	21.07	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{610}$
	45	63.1 45.7	1.285	34.17	21.21	
	90	12.4 96.4	1.287	34.21	21.24	
	135	-31.0 139.8	1.465	33.90	20.94	
	180	-82.7 191.5	1.146	34.15	21.18	
	225	-126.7 235.5	1.274	34.17	21.21	
	270	-172.3 281.1	1.393	34.12	21.16	
	315	146.1 322.7	1.424	33.92	20.96	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		3

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	65.9 Ref.	1.537	35.16	21.12	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{960}$
	45	22.3 43.6	1.426	35.14	21.11	
	90	-35.0 100.4	1.533	35.23	21.19	
	135	-61.1 135.0	1.457	35.12	21.09	
	180	-132.7 198.6	1.542	35.09	21.05	
	225	-161.4 235.2	1.385	35.16	21.13	
	270	138.6 287.3	1.458	35.20	21.17	
	315	103.2 322.7	1.339	35.14	21.10	
2257.5	0	-122.5 Ref.	1.220	35.16	21.20	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{850}$
	45	-167.5 45.0	1.185	35.24	21.27	
	90	145.5 92.0	1.116	35.11	21.14	
	135	102.6 134.9	1.283	34.91	20.94	
	180	48.8 188.7	1.312	35.08	21.11	
	225	4.5 233.0	1.469	35.33	21.36	
	270	-43.0 280.5	1.312	35.09	21.12	
	315	-85.4 322.9	1.414	34.97	21.01	
2287.5	0	108.7 Ref.	1.374	34.21	20.21	$I_{5V} = \underline{99}$ $I_{12V} = \underline{34}$ $I_{22V} = \underline{650}$
	45	62.2 46.5	1.226	34.34	20.34	
	90	11.8 96.9	1.348	34.29	20.29	
	135	-30.4 139.1	1.485	34.02	20.02	
	180	-83.0 191.7	1.297	34.25	20.25	
	225	-126.3 235.0	1.357	34.32	20.32	
	270	-172.3 281.0	1.520	34.20	20.20	
	315	146.9 321.8	1.469	34.05	20.05	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-98.4 Ref.	1.527	31.2	16.078	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	-144.0 45.6	1.601	30.9	16.739	
	90	-176.0 77.6	1.738	28.0	17.035	
	135	145.4 116.2	1.816	29.4	17.329	
	180	81.2 180.4	1.858	31.1	16.455	
	225	34.9 226.7	1.792	31.2	16.476	
	270	-3.6 265.2	1.783	28.4	16.376	
	315	-40.9 302.5	1.766	29.6	16.994	
2041.9	0	-162.1 Ref.	1.301	32.0	14.907	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	149.7 48.2	1.345	32.2	14.874	
	90	116.5 81.4	1.330	29.8	15.197	
	135	76.8 121.1	1.354	30.96	15.849	
	180	16.0 181.9	1.254	32.2	14.424	
	225	30.4 228.3	1.181	32.8	14.571	
	270	-68.5 266.4	1.199	30.2	14.994	
	315	-108.2 306.1	1.220	31.2	15.737	
2052.9	0	139.7 Ref.	1.711	32.61	13.797	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	90.8 48.1	1.718	32.75	14.470	
	90	56.4 82.5	1.696	29.85	14.191	
	135	14.0 124.9	1.691	30.9	13.867	
	180	-41.1 180.0	1.486	32.7	13.210	
	225	-88.1 227.0	1.435	33.2	13.159	
	270	-127.8 266.7	1.554	30.3	14.151	
	315	-170.5 309.4	1.625	30.99	14.138	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	27.2 Ref.	1.252	32.8	3.614	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	-22.3 49.5	1.243	32.2	12.811	
	90	-52.7 79.9	1.273	29.6	12.555	
	135	-92.8 120.0	1.260	30.6	13.063	
	180	-145.0 175.2	1.140	32.9	14.008	
	225	159.7 227.5	1.038	32.7	13.083	
	270	122.5 264.7	1.181	29.96	12.514	
	315	81.8 305.4	1.227	30.7	12.937	
2095.4	0	-77.0 Ref.	1.255	31.95	14.403	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	-122.6 45.6	1.326	31.0	14.614	
	90	-152.2 75.2	1.396	28.8	14.583	
	135	163.1 119.9	1.488	20.2	14.695	
	180	106.7 176.3	1.498	32.2	14.185	
	225	59.0 224.0	1.386	31.5	13.980	
	270	23.9 259.1	1.281	29.1	13.650	
	315	-18.8 301.8	1.260	30.4	13.835	
2106.4	0	-134.0 Ref.	1.772	31.5	15.672	I _{5V} = <u>97</u> I _{12V} = <u>35</u>
	45	179.5 46.5	1.773	30.8	15.319	
	90	150.0 76.0	1.741	29.3	15.781	
	135	104.9 121.1	1.685	30.96	17.015	
	180	50.5 175.5	1.446	31.9	15.457	
	225	3.7 222.3	1.342	31.5	14.989	
	270	-30.1 256.1	1.426	29.6	15.230	
	315	-73.5 299.5	1.483	30.95	16.505	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

11-7913C

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INPUT POWER LEVEL = -40 DBM

****Only 0° setting is measured on center modules (P/N SK446962-1)**

TI-7915C

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	7.10	1127	+3.75	-28.4	32.15
2041.9	6.05	878	+4.57	-29.5	34.09
2052.9	5.9	838	+3.63	-28.3	31.93
2074.15	6.6	1036	+0.07	-22.7	23.97
2095.4	6.2	919	+5.83	-26.2	32.03
2106.4	5.8	812	+8.06	-27.6	35.66
2117.4	5.85	825	+3.67	-29.2	27.87

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-8.0	--	—	OFF/2041.9	1.6:1
-40	-10.0	> +35	+6.0	2217.5/2041.9	1.6:1
-40	-8.5	--	—	OFF/2106.4	1.6:1
-40	-9.0	> +35	-3.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		8

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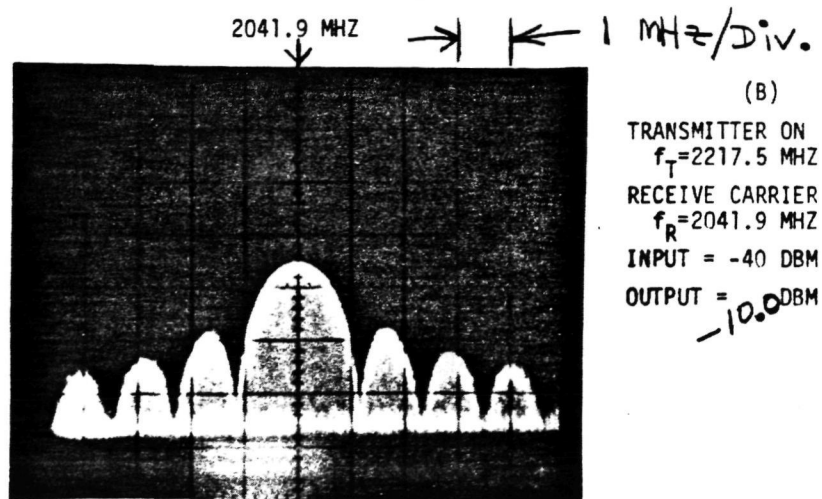
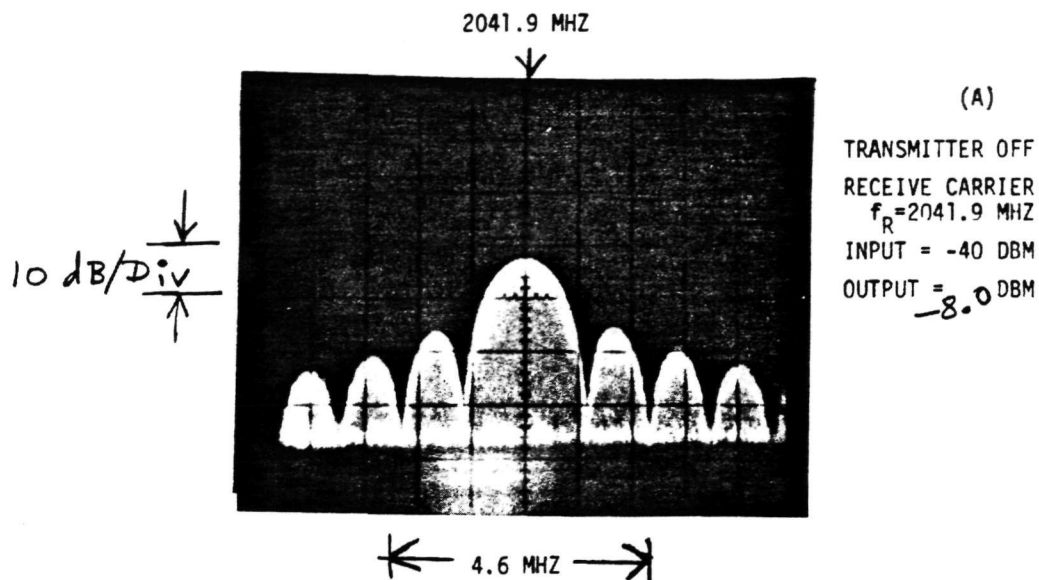
TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR	1.05:1	> 30	> 40	> 40	—
2217.5/2041.9					
2217.5/2041.9	1.6:1	> 30	2390 MHz — > 20	> 40	—
2287.5/2106.4	1.05:1	> 40	> 40	> 40	—
2287.5/2106.4	1.6:1	> 30	> 40	> 40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 5

B-~~45~~
45

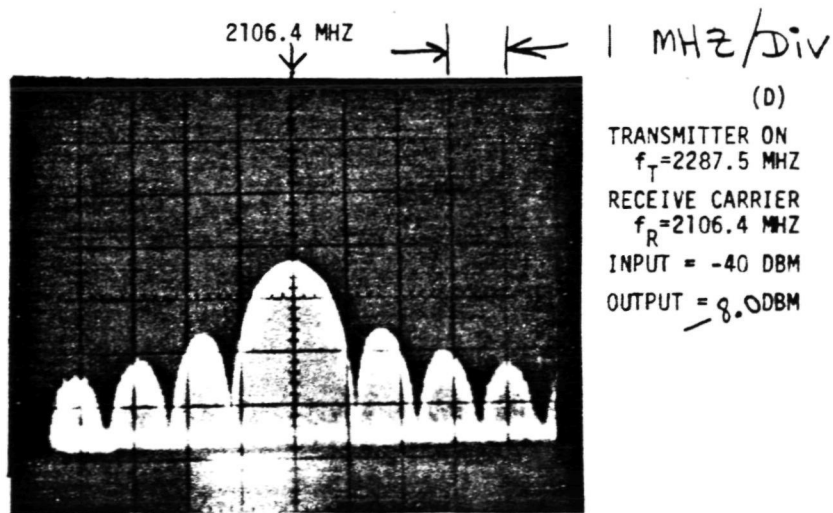
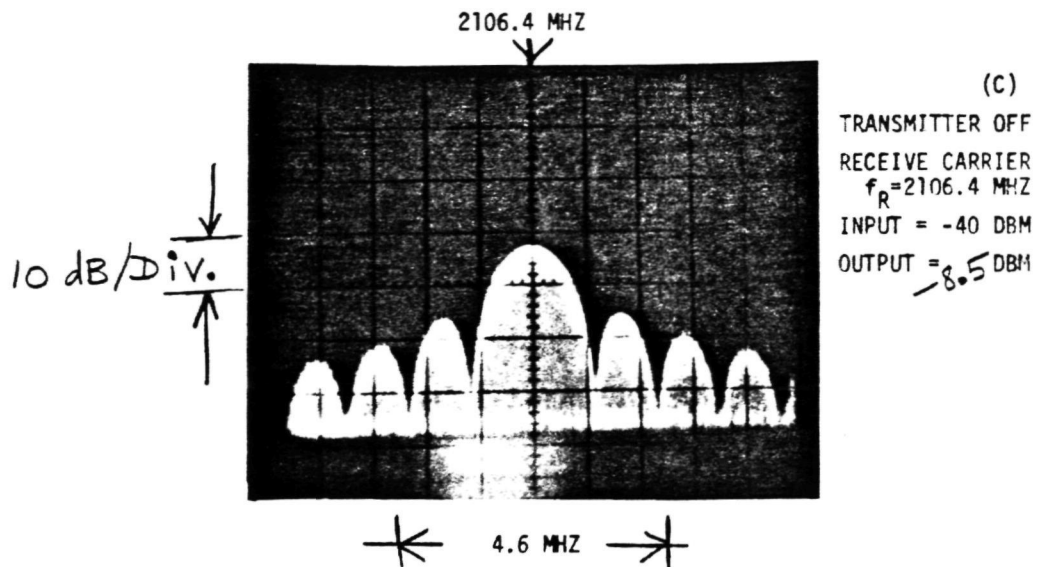
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 10 5

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TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		11

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600 1775.5 1803.65 1831.8 2000	N.A. ↓	N.A. ↓	N.A. ↓

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	83.2 Ref.	1.659	34.97	22.97	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>720</u>
	45	42.0 41.2	1.215	35.21	23.21	
	90	-2.2 85.4	2.082	34.63	22.64	
	135	-40.5 123.7	2.090	34.76	22.76	
	180	-106.4 187.6	1.626	34.56	22.56	
	225	-144.6 227.8	1.151	34.83	22.83	
	270	168.4 274.8	1.919	34.77	22.77	
	315	128.4 314.8	1.941	34.75	22.75	
2257.5	0	-139.8 Ref.	1.390	36.07	24.07	I _{5V} = <u>101</u> I _{12V} = <u>42</u> I _{22V} = <u>770</u>
	45	175.2 45.0	2.069	35.81	23.81	
	90	136.1 84.1	1.396	35.68	23.68	
	135	87.8 132.4	1.154	35.82	23.82	
	180	38.5 181.7	1.045	35.91	23.91	
	225	-7.9 228.1	1.359	35.79	23.80	
	270	-47.3 269.5	1.175	35.65	23.65	
	315	-96.1 316.3	1.221	35.72	23.72	
2287.5	0	68.9 Ref.	1.690	35.61	23.61	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>740</u>
	45	34.4 34.5	1.952	35.51	23.51	
	90	-25.4 94.3	1.348	35.28	23.29	
	135	-66.0 134.9	1.294	35.25	23.25	
	180	-114.9 183.8	1.387	35.44	23.44	
	225	-149.5 219.4	1.528	35.25	23.25	
	270	154.1 274.8	1.260	35.34	23.34	
	315	111.8 317.1	1.194	35.46	23.46	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 2

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.2 Ref.	1.823	34.96	21.95	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>730</u>
	45	42.8 39.4	1.259	35.12	22.11	
	90	-12.5 94.7	2.055	35.06	22.05	
	135	-43.3 125.5	2.071	34.91	21.90	
	180	-108.5 190.7	1.790	34.73	21.73	
	225	-144.9 227.1	1.288	34.94	21.93	
	270	160.0 282.2	1.895	35.03	22.02	
	315	127.1 315.1	1.909	34.91	21.90	
2257.5	0	-138.9 Ref.	1.408	35.96	22.98	I _{5V} = <u>101</u> I _{12V} = <u>42</u> I _{22V} = <u>780</u>
	45	176.1 45.0	1.615	35.83	22.85	
	90	134.5 86.6	1.282	35.73	22.75	
	135	88.5 132.6	1.309	35.84	22.85	
	180	38.4 182.7	1.206	35.96	22.98	
	225	-6.5 227.6	1.255	35.89	22.91	
	270	-49.0 270.1	1.150	35.74	22.76	
	315	-95.6 316.7	1.328	35.76	22.78	
2287.5	0	65.5 Ref.	1.552	35.70	22.73	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>780</u>
	45	28.1 37.4	1.536	35.64	22.67	
	90	-27.1 92.6	1.483	35.33	22.36	
	135	-66.3 131.8	1.436	35.34	22.37	
	180	-119.0 184.5	1.368	35.63	22.66	
	225	-156.3 221.8	1.214	35.48	22.51	
	270	150.9 274.6	1.403	35.41	22.44	
	315	111.6 313.9	1.347	35.57	22.60	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 6

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.7 Ref.	1.989	34.85	20.85	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>140</u>
	45	44.4 38.3	1.404	34.97	20.99	
	90	-13.4 96.1	1.914	35.02	21.03	
	135	-43.6 126.3	2.055	34.93	20.94	
	180	-108.0 190.7	1.965	34.69	20.71	
	225	-143.5 226.2	1.463	34.85	20.86	
	270	160.3 292.4	1.806	34.99	21.00	
	315	127.3 315.4	1.900	34.85	20.86	
2257.5	0	-137.9 Ref.	1.559	35.91	21.93	I _{5V} = <u>101</u> I _{12V} = <u>42</u> I _{22V} = <u>190</u>
	45	177.8 44.3	1.454	35.86	21.88	
	90	133.3 88.8	1.257	35.77	21.79	
	135	89.4 132.7	1.485	35.82	21.84	
	180	38.8 183.3	1.384	35.97	21.99	
	225	-5.0 227.1	1.327	35.95	21.97	
	270	-49.6 271.7	1.251	35.74	21.76	
	315	-94.7 316.8	1.510	35.71	21.73	
2287.5	0	66.6 Ref.	1.656	35.72	21.72	I _{5V} = <u>101</u> I _{12V} = <u>41</u> I _{22V} = <u>800</u>
	45	27.8 38.8	1.289	35.61	21.70	
	90	-27.7 94.3	1.611	35.35	21.36	
	135	-65.5 132.1	1.628	35.40	21.41	
	180	-118.2 184.8	1.516	35.67	21.67	
	225	-155.8 222.4	1.225	35.59	21.59	
	270	149.0 277.6	1.585	35.45	21.46	
	315	112.4 314.2	1.551	35.59	21.60	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta \phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-78.2 Ref.	1.797	32.18	13.98	I _{5V} = <u>100</u> I _{12V} = <u>42</u>
	45	-122.1 43.9	1.877	32.59	14.66	
	90	-160.9 82.7	1.618	32.01	14.87	
	135	157.6 124.2	1.598	31.28	13.96	
	180	103.6 178.2	1.649	31.90	13.33	
	225	62.3 219.5	1.683	32.23	13.90	
	270	15.0 266.8	1.657	32.21	13.94	
	315	-26.3 308.1	1.693	31.86	13.75	
2041.9	0	-133.6 Ref.	1.315	33.11	15.94	I _{5V} = <u>100</u> I _{12V} = <u>42</u>
	45	179.8 46.6	1.354	33.17	15.42	
	90	140.2 86.2	1.343	32.35	14.36	
	135	102.3 124.1	1.351	31.92	14.47	
	180	50.7 175.7	1.395	32.27	14.49	
	225	7.3 219.1	1.445	32.95	14.67	
	270	-40.2 266.6	1.438	32.98	14.64	
	315	-80.8 307.2	1.487	32.66	14.95	
2052.9	0	163.2 Ref.	1.908	33.22	13.21	I _{5V} = <u>100</u> I _{12V} = <u>42</u>
	45	118.7 44.5	1.769	33.58	12.98	
	90	83.3 79.9	1.714	32.79	13.50	
	135	45.0 118.2	1.682	32.50	13.99	
	180	-6.7 169.9	1.556	33.29	13.54	
	225	-50.8 214.0	1.580	34.24	14.09	
	270	-98.1 261.3	1.643	33.81	14.06	
	315	-140.0 303.2	1.666	33.34	14.61	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	65.9 Ref.	2.44	33.09	12.32	$I_{5V} = 100$ $I_{12V} = 42$
	45	19.6 46.3	2.39	32.55	12.55	
	90	-17.8 83.7	2.79	32.11	12.35	
	135	-59.2 125.1	2.92	32.37	12.74	
	180	-107.6 173.5	2.68	32.89	12.68	
	225	-156.8 222.7	2.54	33.11	13.09	
	270	156.5 269.4	2.58	32.36	12.12	
	315	114.1 311.8	2.58	32.23	11.99	
2095.4	0	-33.8 Ref.	1.289	33.88	16.92	$I_{5V} = 100$ $I_{12V} = 42$
	45	-82.7 48.9	1.571	33.57	14.44	
	90	-119.8 86.0	1.753	32.80	14.55	
	135	-167.8 131.0	1.828	32.37	14.04	
	180	146.7 177.5	1.737	32.93	12.86	
	225	101.6 224.6	1.637	32.99	12.78	
	270	58.8 267.4	1.609	32.41	13.24	
	315	15.7 310.5	1.604	32.21	12.90	
2106.4	0	-88.7 Ref.	1.289	33.88	16.92	$I_{5V} = 100$ $I_{12V} = 42$
	45	-139.9 51.2	1.255	33.58	16.78	
	90	-177.4 88.7	1.483	32.63	15.65	
	135	139.7 131.6	1.561	32.38	14.59	
	180	97.7 173.6	1.507	33.01	14.71	
	225	50.9 220.4	1.459	32.81	14.71	
	270	6.4 264.9	1.418	32.65	14.74	
	315	-35.4 306.7	1.412	32.69	14.75	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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INPUT POWER LEVEL = -40 DBM

****Only 0° setting is measured on center modules (P/N SK446962-1)**

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	5.95	852	+6.95	-23.94	30.89
2041.9	5.7	757	+8.3	-23.97	32.28
2052.9	5.5	739	+7.67	-27.89	35.56
2074.15	5.8	813	+5.47	-25.33	33.80
2095.4	5.1	648	+8.87	-25.63	34.50
2106.4	4.9	607	+8.84	-24.34	33.18
2117.4	4.8	586	+8.83	-24.46	33.29

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-11.0	> +35	+8.0	2217.5/2041.9	1.6:1
-40	-6.0	--	—	OFF/2106.4	1.6:1
-40	-6.0	> +35	-18.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

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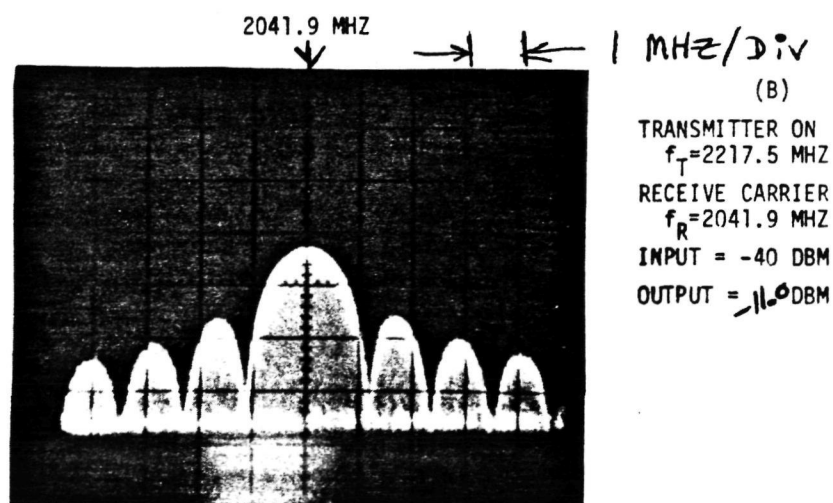
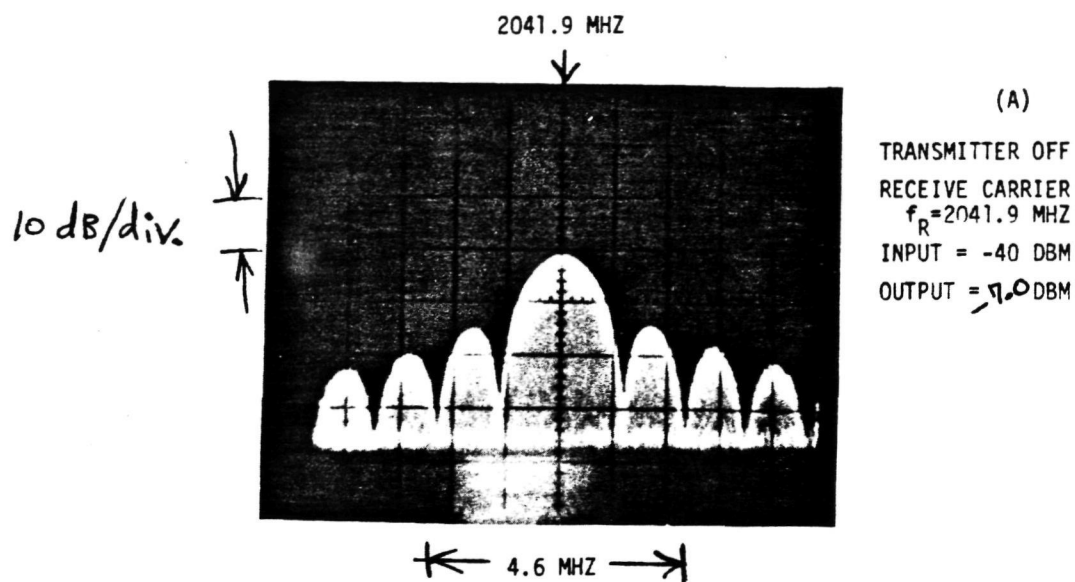
TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

FREQUENCY (MHZ)	LOAD VSWR	INTERMODULATION FREQUENCY/DBC			
		F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2890 MHz >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 9 6

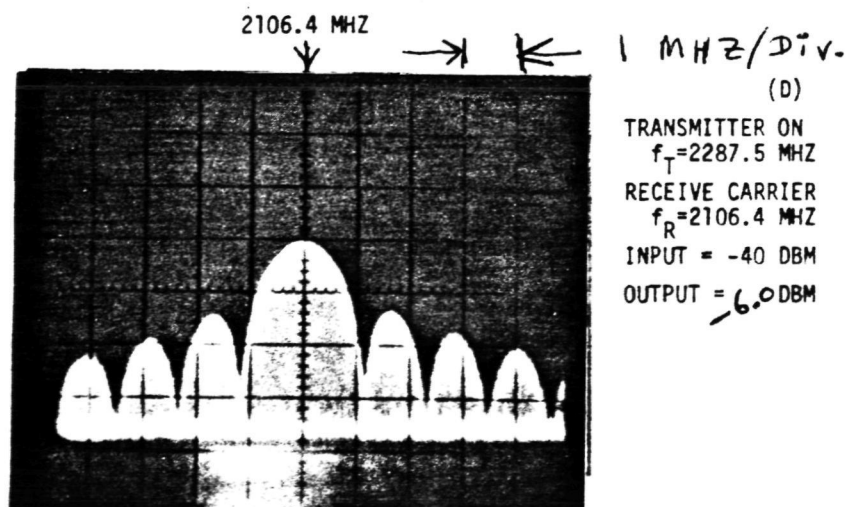
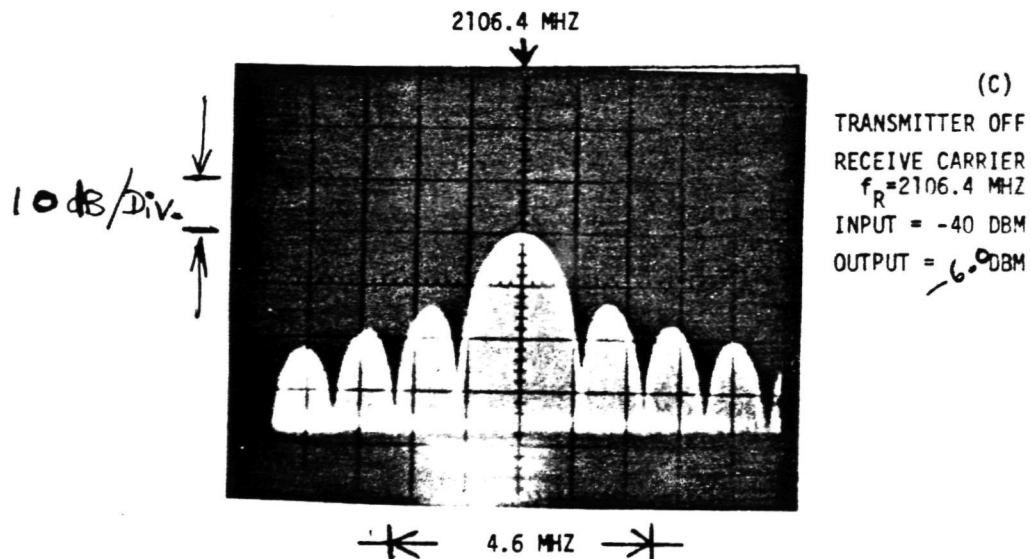
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TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 10 58 6

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B- 59 59
SCALE	REV	SHEET	11

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600 1775.5 1803.65 1831.8 2000	N. A. ↓	N. A. ↓	N. A. ↓

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B- 60 60
SCALE	REV	SHEET	12

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.1 Ref.	1.644	35.81	23.83	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 1020$
	45	11.1 40.0	1.552	35.54	23.85	
	90	-52.5 103.6	1.088	35.62	23.64	
	135	-86.6 137.7	1.367	35.59	23.60	
	180	-141.1 192.2	1.508	35.76	23.77	
	225	-179.4 230.5	1.418	35.78	23.75	
	270	134.9 276.2	1.132	35.64	23.66	
	315	96.6 314.5	1.242	35.79	23.80	
2257.5	0	-132.0 Ref.	1.723	36.00	24.20	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 880$
	45	179.1 48.9	1.306	36.15	24.16	
	90	128.9 99.1	1.144	36.21	24.21	
	135	85.6 142.4	1.466	36.23	24.22	
	180	35.5 192.5	1.455	36.21	24.21	
	225	-10.4 238.4	1.617	36.14	24.14	
	270	-54.2 282.2	1.408	35.95	23.96	
	315	-96.5 324.5	1.995	36.10	24.10	
2287.5	0	91.8 Ref.	1.185	35.42	23.43	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 730$
	45	42.6 41.2	1.702	35.05	23.06	
	90	-8.4 100.2	1.595	35.13	23.14	
	135	-43.1 134.9	1.847	34.70	22.71	
	180	-85.2 177.0	1.401	34.83	22.85	
	225	-145.7 239.5	1.774	34.99	23.00	
	270	171.6 280.2	2.142	34.93	22.95	
	315	148.0 303.8	2.456	34.26	22.27	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES, Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.5 Ref.	1.501	35.67	22.68	I _{5V} = <u>102</u> I _{12V} = <u>34</u> I _{22V} = <u>1020</u>
	45	11.8 39.7	1.576	35.72	22.73	
	90	-50.5 102.0	1.252	35.52	22.52	
	135	-89.4 140.9	1.212	35.51	22.52	
	180	-139.4 190.9	1.351	35.65	22.65	
	225	-177.2 228.7	1.368	35.63	22.63	
	270	136.7 274.8	1.303	35.54	22.54	
	315	99.0 312.5	1.129	35.63	22.64	
2257.5	0	-133.7 Ref.	1.122	36.14	23.13	I _{5V} = <u>102</u> I _{12V} = <u>34</u> I _{22V} = <u>900</u>
	45	179.8 46.5	1.219	36.06	23.06	
	90	129.3 97.0	1.047	36.11	23.10	
	135	87.0 139.3	1.476	36.19	23.19	
	180	35.7 190.6	1.229	36.17	23.16	
	225	-8.1 234.4	1.465	36.03	23.02	
	270	-52.8 279.1	1.358	35.87	22.86	
	315	-94.1 320.4	1.767	36.04	23.03	
2287.5	0	82.6 Ref.	1.065	35.56	22.55	I _{5V} = <u>102</u> I _{12V} = <u>34</u> I _{22V} = <u>780</u>
	45	37.5 45.1	1.656	35.25	22.24	
	90	-12.6 95.2	1.465	35.27	22.26	
	135	-56.0 138.6	1.590	35.29	22.29	
	180	-100.7 183.3	1.302	35.39	22.38	
	225	-148.5 231.1	1.671	35.16	22.15	
	270	165.2 277.4	1.139	35.23	22.22	
	315	129.4 313.2	2.097	35.25	22.24	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 7

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.9 Ref.	1.427	35.62	21.63	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 1030$
	45	13.0 38.9	1.624	35.71	21.68	
	90	-48.5 100.4	1.436	35.50	21.47	
	135	-87.3 139.2	1.239	35.45	21.42	
	180	-138.0 189.9	1.285	35.62	21.50	
	225	-175.3 227.2	1.383	35.63	21.57	
	270	138.5 273.4	1.475	35.55	21.51	
	315	101.5 310.4	1.239	35.60	21.57	
2257.5	0	-134.8 Ref.	1.221	36.14	22.13	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 920$
	45	-179.5 44.7	1.275	36.01	21.99	
	90	127.8 95.4	1.213	36.04	22.03	
	135	87.9 137.3	1.597	36.16	22.15	
	180	36.1 189.1	1.116	36.12	22.11	
	225	-6.3 231.5	1.443	35.99	21.98	
	270	-51.3 276.5	1.438	35.84	21.82	
	315	-92.0 317.2	1.703	36.05	22.04	
2287.5	0	78.8 Ref.	1.159	35.57	21.57	$I_{5V} = 102$ $I_{12V} = 34$ $I_{22V} = 810$
	45	35.3 43.5	1.721	35.33	21.33	
	90	-14.8 93.6	1.489	35.33	21.33	
	135	-58.4 137.2	1.538	35.37	21.29	
	180	-107.9 186.7	1.358	35.48	21.48	
	225	-149.9 228.7	1.672	35.23	21.23	
	270	163.5 275.3	1.894	35.34	21.34	
	315	124.8 314.0	1.827	35.49	21.49	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-99.6 Ref.	2.149	28.51	13.894	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	-141.9 42.3	2.155	28.25	13.527	
	90	-178.9 79.3	2.180	28.05	12.765	
	135	141.9 118.5	2.051	28.54	13.277	
	180	92.6 177.8	2.075	28.85	13.540	
	225	38.6 221.8	2.112	28.60	13.751	
	270	-2.6 262.0	2.203	28.67	13.268	
	315	-43.6 304.0	2.177	29.14	13.806	
2041.9	0	-154.7 Ref.	1.581	30.46	15.004	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	164.5 40.8	1.583	29.93	15.189	
	90	130.6 74.7	1.580	29.62	15.316	
	135	89.3 116.0	1.590	30.31	16.569	
	180	27.0 176.3	1.606	30.74	15.436	
	225	-15.9 221.1	1.568	30.80	16.121	
	270	-55.1 260.4	1.556	30.29	15.615	
	315	-98.3 303.6	1.572	30.58	15.693	
2052.9	0	145.9 Ref.	2.414	30.82	13.750	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	104.4 41.5	2.351	30.07	13.809	
	90	69.9 76.0	2.233	30.33	13.966	
	135	23.7 122.2	2.599	31.71	14.851	
	180	-32.1 178.0	2.571	31.85	14.490	
	225	-79.7 225.8	2.419	31.16	13.858	
	270	-117.0 262.9	2.185	30.76	13.212	
	315	-160.4 306.3	2.277	31.34	13.506	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES $\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	41.8 Ref.	2.125	30.03	12.671	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	1.9 39.9	2.116	29.65	13.239	
	90	-39.7 79.5	2.172	30.46	13.789	
	135	-89.9 131.7	2.341	30.57	12.795	
	180	-131.5 180.3	2.338	30.65	12.304	
	225	179.4 222.4	2.149	29.71	12.385	
	270	142.5 259.3	2.103	29.98	13.209	
	315	94.6 307.2	2.166	30.22	12.777	
2095.4	0	-59.1 Ref.	1.705	29.77	12.750	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	-100.7 41.6	1.674	29.55	12.678	
	90	-141.6 82.5	1.562	29.88	12.777	
	135	171.8 129.1	1.658	29.23	12.607	
	180	123.7 177.2	1.684	29.64	11.982	
	225	82.1 218.8	1.759	29.37	11.855	
	270	41.9 259.0	1.710	30.00	12.577	
	315	-4.5 305.4	1.671	29.81	12.468	
2106.4	0	-109.6 Ref.	1.702	30.36	16.782	I _{5V} = <u>100</u> I _{12V} = <u>34</u>
	45	-150.9 41.3	1.647	29.74	16.610	
	90	161.8 82.6	1.529	29.83	15.780	
	135	121.9 128.5	1.739	29.81	15.622	
	180	76.3 174.1	1.765	30.26	15.518	
	225	35.2 215.2	1.850	29.87	16.057	
	270	-7.9 258.3	1.773	30.25	15.607	
	315	-53.8 304.2	1.761	30.43	15.607	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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INPUT POWER LEVEL = -40 DBM

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	7.3	1267	+1.85	-23.4	25.2
2041.9	6.9	1131	+1.7	-24.8	26.5
2052.9	6.7	1067	+0.27	-25.9	26.3
2074.15	6.8	1098	+5.43	-25.1	33.5
2095.4	5.9	838	+6.83	-27.3	34.1
2106.4	5.6	763	+5.66	-27.5	31.7
2117.4	5.7	788	+5.47	-26.0	31.5

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-9.0	--	—	OFF/2041.9	1.6:1
-40	-11.0	> +35	+1.0	2217.5/2041.9	1.6:1
-40	-10.0	--	—	OFF/2106.4	1.6:1
-40	-10.0	> +35	-12.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		8

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68

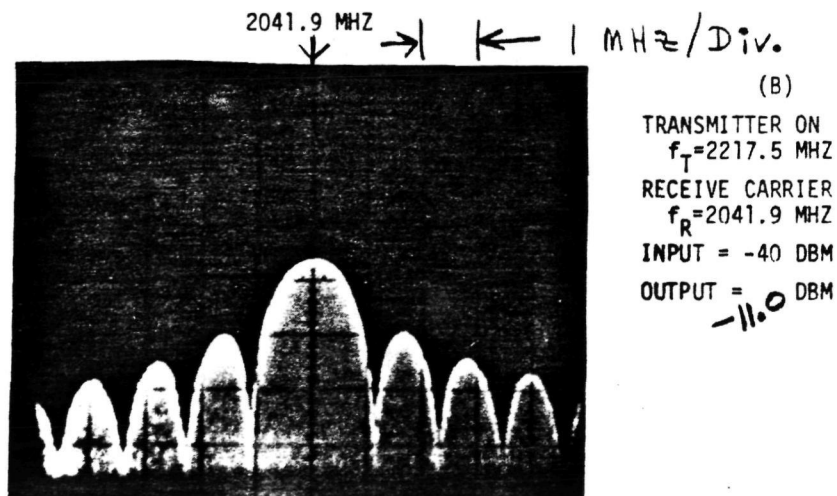
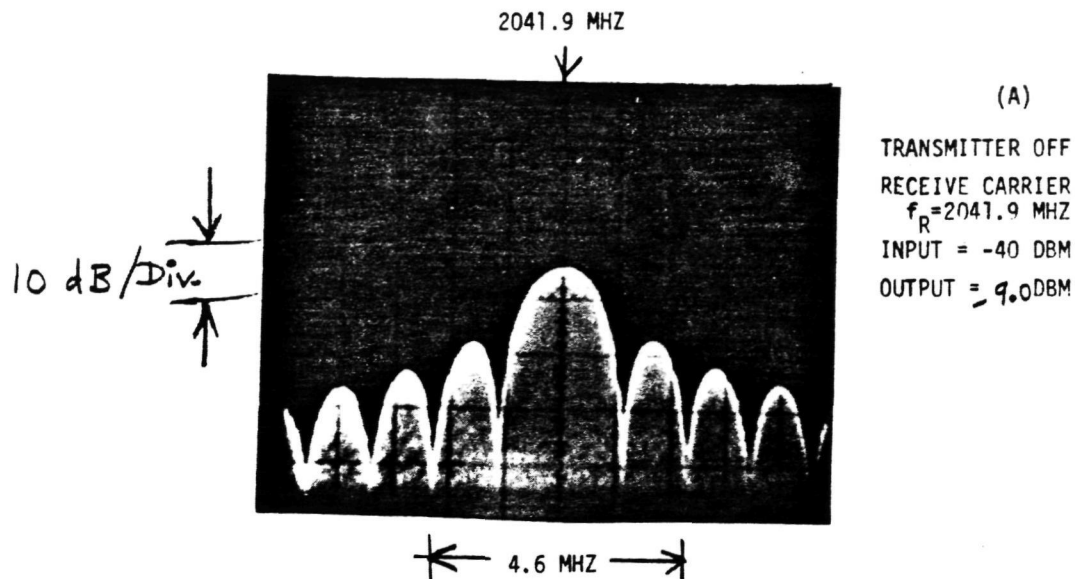
TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR	1.05:1	> 30	> 40	> 40	—
2217.5/2041.9					
2217.5/2041.9	1.6:1	> 30	2390 MHz	> 40	—
			> 20		
2287.5/2106.4	1.05:1	> 40	> 40	> 40	—
2287.5/2106.4	1.6:1	> 30	> 40	> 40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 7

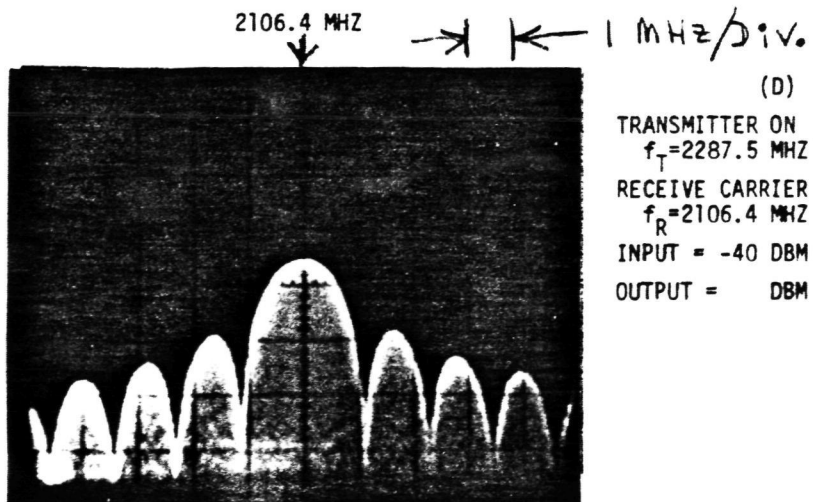
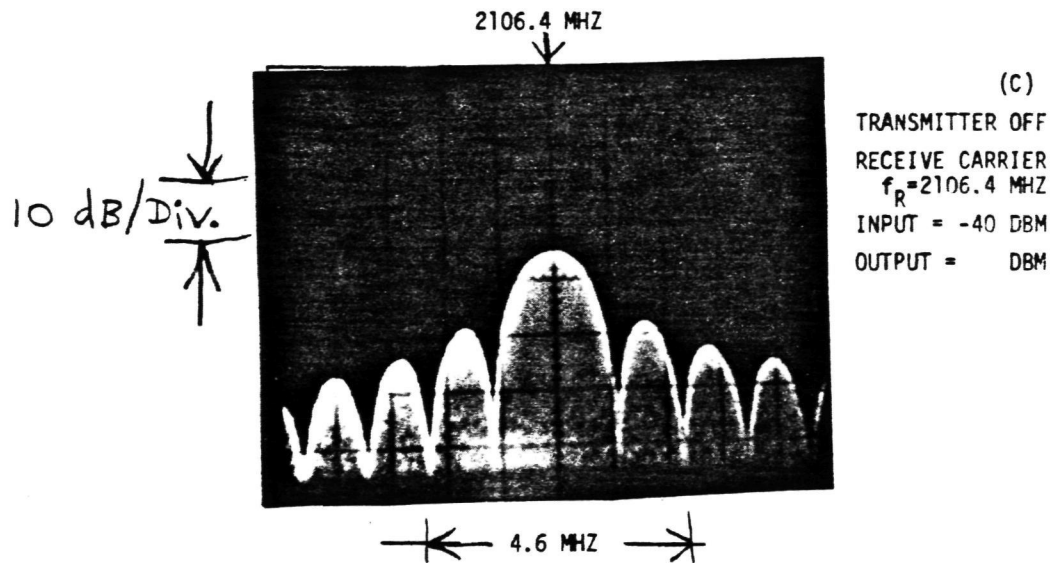
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TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		10

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 11 7

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600 1775.5 1803.65 1831.8 2000	N.A. ↓	N.A. ↓	N.A. ↓

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

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APPENDIX C

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	36.1	Ref.	1.215	35.34	23.36	I _{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = 43
	90						
	135						
	180						
	225						I _{22V} = 950
	270						
	315	↓	↓	↓	↓	↓	
2257.5	0	-119.4	Ref.	1.084	35.15	23.15	I _{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = 43
	90						
	135						
	180						
	225						I _{22V} = 710
	270						
	315	↓	↓	↓	↓	↓	
2287.5	0	108.0	Ref.	1.044	34.84	22.84	I _{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = 43
	90						
	135						
	180						
	225						I _{22V} = 610
	270						
	315	↓	↓	↓	↓	↓	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET
		2 2

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	37.9	Ref.	1.378	35.23	22.22	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>43</u>
	90	↓	↓	↓	↓	↓	I _{22V} = <u>960</u>
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	
2257.5	0	121.5	Ref.	1.215	35.54	22.56	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>43</u>
	90	↓	↓	↓	↓	↓	I _{22V} = <u>760</u>
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	
2287.5	0	105.9	Ref.	1.160	34.99	21.99	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>43</u>
	90	↓	↓	↓	↓	↓	I _{22V} = <u>650</u>
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	39.7	Ret.	1.541	35.21	21.18	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>73</u>
	90						I _{22V} = <u>970</u>
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	
2257.5	0	423.6	Ret.	1.417	35.84	21.83	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>43</u>
	90						I _{22V} = <u>800</u>
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	
2287.5	0	104.6	Ret.	1.319	35.08	21.08	I _{5V} = <u>0</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I _{12V} = <u>43</u>
	90						I _{22V} = <u>680</u>
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-99.9	Ref.	2.282	31.18	13.03	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	
2041.9	0	-151.5	Ref.	3.198	27.26	8.93	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	
2052.9	0	173.1	Ref.	3.826	25.48	8.512	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135						
	180						
	225						
	270						
	315	↓	↓	↓	↓	↓	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	98.0	Ref.	3.480	29.7	18.2	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	
2095.4	0	-55.1	Ref.	8.779	32.06	16.75	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	
2106.4	0	-121.4	Ref.	8.640	29.18	16.63	I _{5V} = <u>0</u> I _{12V} = <u>43</u>
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90	↓	↓	↓	↓	↓	
	135	↓	↓	↓	↓	↓	
	180	↓	↓	↓	↓	↓	
	225	↓	↓	↓	↓	↓	
	270	↓	↓	↓	↓	↓	
	315	↓	↓	↓	↓	↓	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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INPUT POWER LEVEL = -40 DBM

****Only 0° setting is measured on center modules (P/N SK446962-1)**

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	6.1	892	+7.75	-23.21	30.97
2041.9	6.3	948	+7.51	-19.87	27.38
2052.9	5.9	838	+9.07	-19.31	28.46
2074.15	5.9	838	+5.77	-21.23	30.00
2095.4	5.8	813	+11.07	-19.75	30.82
2106.4	6.0	865	+8.84	-20.24	29.08
2117.4	6.8	1098	+8.83	-17.86	26.69

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-12.0	--	—	OFF/2041.9	1.6:1
-40	-13.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-9.5	--	—	OFF/2106.4	1.6:1
-40	-10.0	> +35	-5.5	2287.5/2106.4	1.6:1

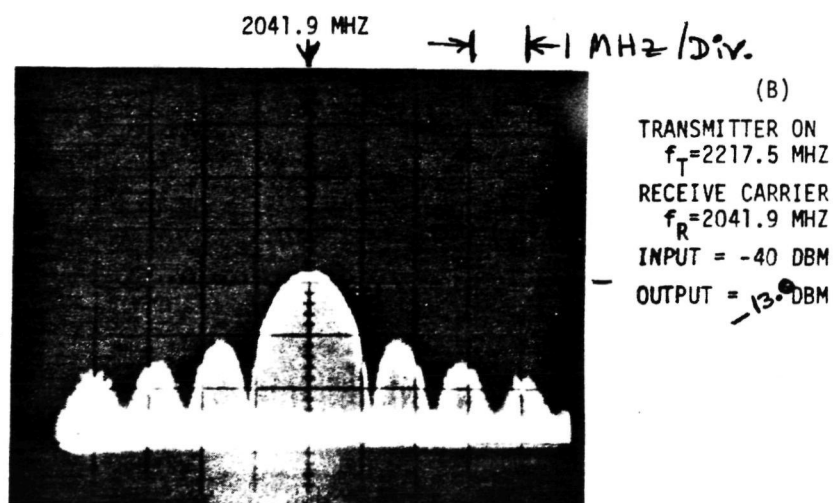
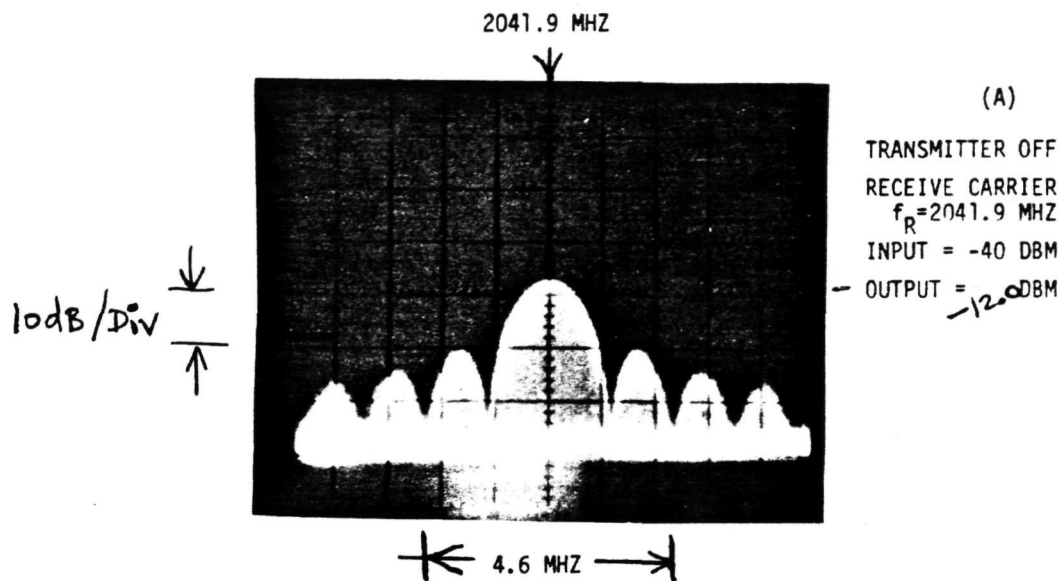
SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8 2

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT
EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR	1.05:1	>30	>40	>40	—
2217.5/2041.9					
2217.5/2041.9	1.6:1	>30	2390 MHz >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

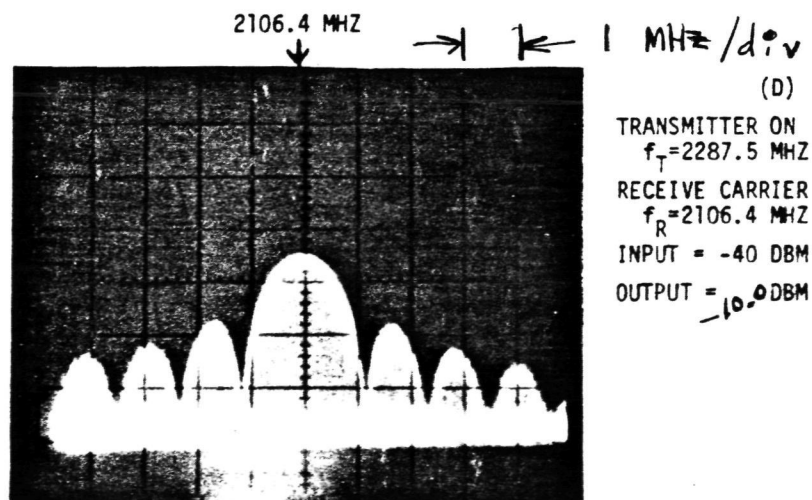
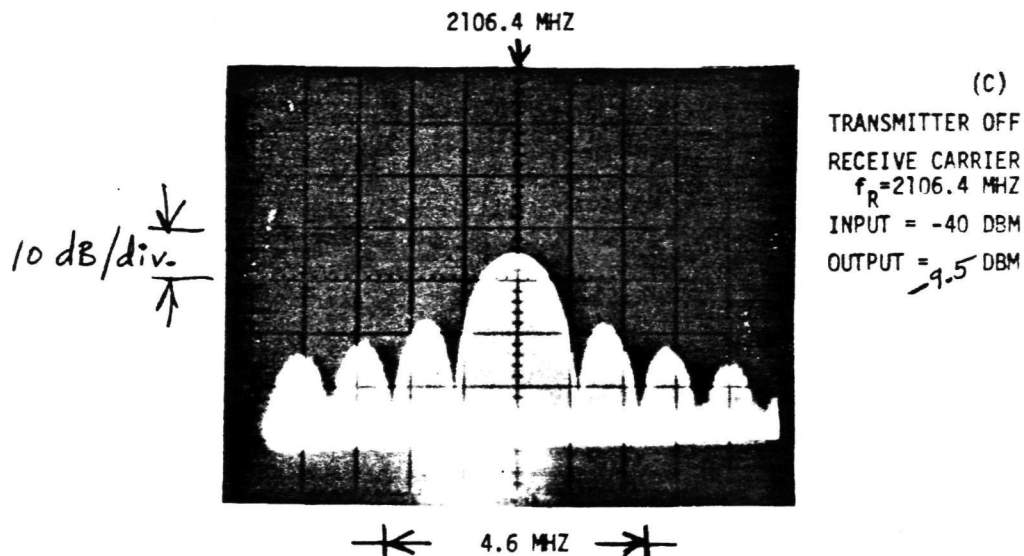
SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 2

TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE
MODULATION TESTS, PHOTOGRAPHS



SIZE	CODE IDENT NO	DRAWING NO		
A	96214	SKDD302	C-10	
SCALE	REV	SHEET	10	2

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET
		11

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER
SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	-2.0	-8.76	1900
1775.5	-15	-3.75	398
1803.65	-15	-3.29	320
1831.8	-20	-3.39	348
2000	-17	-11.85	4150

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 C-12
SCALE	REV	SHEET 12 2



APPENDIX D

D-1

[illegible]

P/N 5K446 961

Contract: NAS9-14485

[illegible]

D-1

SPACS II -
DC & LOGIC MANIFOLD TESTING

1.0 INTRODUCTION

The purpose of this document is to describe the various electrical and mechanical tests that will be performed on the DC and logic manifold.

2.0 DC MANIFOLD ELECTRICAL TESTS

Continuity tests will be performed on the DC manifold (P/N SK446941) to insure that there are no shorted or open pins and that the DC manifold conforms to the requirements called out in Paragraphs 1.2.2, 3.3, and 3.7.4 of Contract NAS9-14485 (Statement of Work).

3.0 DC MANIFOLD COMPATIBILITY CHECKS

The DC manifold will be integrated into the antenna array housing to insure that it is mechanically compatible with the array hardware. In addition, the array wiring harness P/N SK446985 will be plugged into the DC manifold connectors. The appropriate electrical signals will be applied to the array subsystem connector (SK446943) and the DC manifold will be checked with a digital voltmeter and oscilloscope to insure that these input signals are distributed properly to the manifold module connectors (SK446981 and SK 446982).

A further mechanical compatibility check will be made to insure that the T/R modules will plug into the manifold connectors while it is mounted in the antenna array housing (this includes the RF manifolds).

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD501	
SCALE		REV	SHEET 2



APPENDIX E

E-1

SPACS II TESTING

I. INTRODUCTION

The purpose of this document is to describe the test procedure for the SPACS II seven element phased array antenna subsystem. This subsystem is composed of a seven element square spiral antenna array, RF (transmit and receive) manifolds, DC and logic manifold, and seven T/R micro-electronics modules. Both transmit and receive characteristics of this subsystem will be measured. A picture of the array is shown in Figure 1. The array is mounted in a large curved ground plane shown in Figure 2.

II. TRANSMIT EIRP AND PATTERN TESTS

For purposes of obtaining transmit antenna EIRP and patterns the equipment will be arranged as shown in the block diagram in Figure 3. Data will be taken using a rotating linearly polarized receiving horn in order to display axial ratio. Principal plane patterns for the assembled array will be taken about 0° (boresight), 35°, and 70° in the horizontal axis; and 0° (boresight), 25°, and 50° in the vertical plane. Reference gain levels will be included on these patterns. The array will be set to the appropriate scan angles by switching the SPACS control box and manually stepping through each of the module transmit phase shifters sequentially.

The module phase shifter positions for the measured array patterns will be as shown in Table 1. Table 2 give the planes of cut and frequencies of the patterns to be measured. The geometry defining ϕ is shown in Figure 4. The patterns will allow one to obtain sidelobe, beamwidth, and axial ratio information.

In order to measure the transmit EIRP, the standard gain horn shown in Figure 3 is used for comparison (substitution method). The RF switch will be calibrated on an HP network analyzer over the SPACS II frequency band. Since the standard gain horn (SGH) will be mounted on the rear of the ground plane, one need only switch the RF and rotate the positioner 180° in order to obtain a comparison. The input power into the SPACS II array and standard gain horn will be the same, +23.5 dBm over the transmit frequency band. Since the gain of the SPACS II array is greater than the SGH, linearity in the RF and IF receiving sections will be checked while transmitting with the SPACS II array. Table 3 gives the transmit frequencies at which EIRP measurements will be

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 2

made. Only on-boresight EIRP data is required by the contract. EIRP values at the additional scan angles are shown for information purposes only.

Since we will know the input power to the array and since Table 3 includes all the necessary data to calculate the array gain, the transmit EIRP can also be easily determined. In this instance, the gain is referred to a matched circularly polarized isotropic source. The G_{cp} gain is related to the axial ratio and linear gain via:

$$G_{cp} = G_{linear} + b$$

where $G_{linear} = G_{SGH} + \Delta dB$

$$b = 10 \log (1+r^2)$$

and $r = 10^{-a/20}$

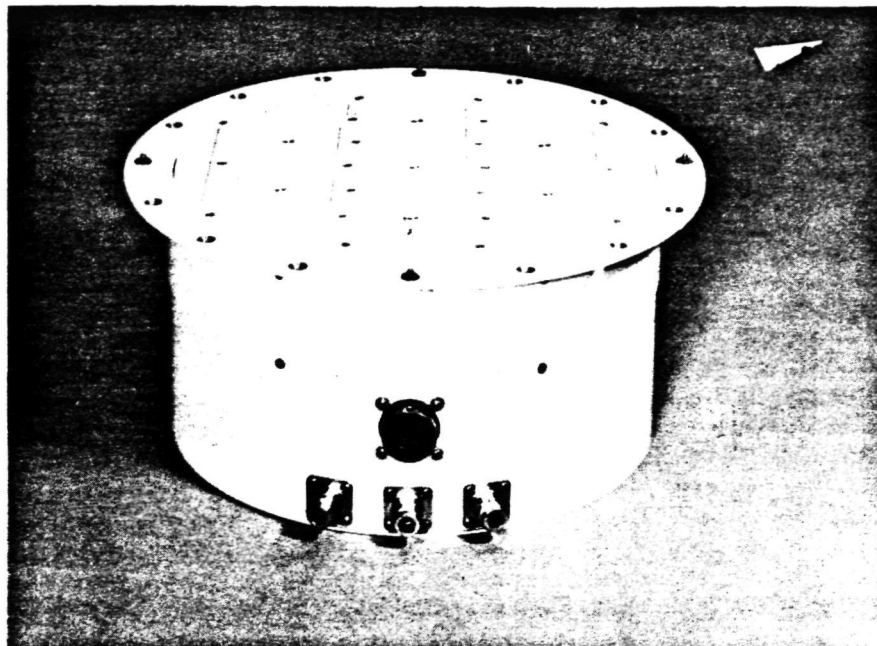
$$a = \text{axial ratio in dB}$$

Here G_{linear} is the gain of the maximum envelope of the rotating linear polarization; and a is the difference between maximum and minimum envelopes. The terminology is defined more clearly in Figure 5. Note that in addition to gain versus frequency in Table 3, we also obtain axial ratio versus frequency.

III. RECEIVE GAIN AND PATTERN TESTS

For purposes of obtaining receive antenna patterns and gain, the equipment will be arranged as shown in the block diagram of Figure 6. Data will be taken using a rotating linearly polarized transmitting horn in order to display axial ratio. Principal plane patterns will be taken about 0° (boresight), 35°, and 70° in the horizontal axis; and 0° (boresight), 25°, and 50° in the vertical plane. Reference gain levels will be included on these patterns. The array will be set to the appropriate scan angles by switching the SPACS control box and manually stepping through each of the module receive phase shifters sequentially. The module phase receive shifter positions for the measured array patterns will be the same as shown in Table 1. Table 4 gives the planes of cut and frequencies of the patterns to be measured. Care must be taken to insure that the transmitting horn is limited in radiated power so that the SPACS II array is operated in its receiver linear gain region. This will be checked before tests are made. Similar gain and axial ratio calculations can be made for the receiver as was made for the transmitter. Table 5 gives the receive frequencies at which measurements will be made for informational purposes only.

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 3



1207-19

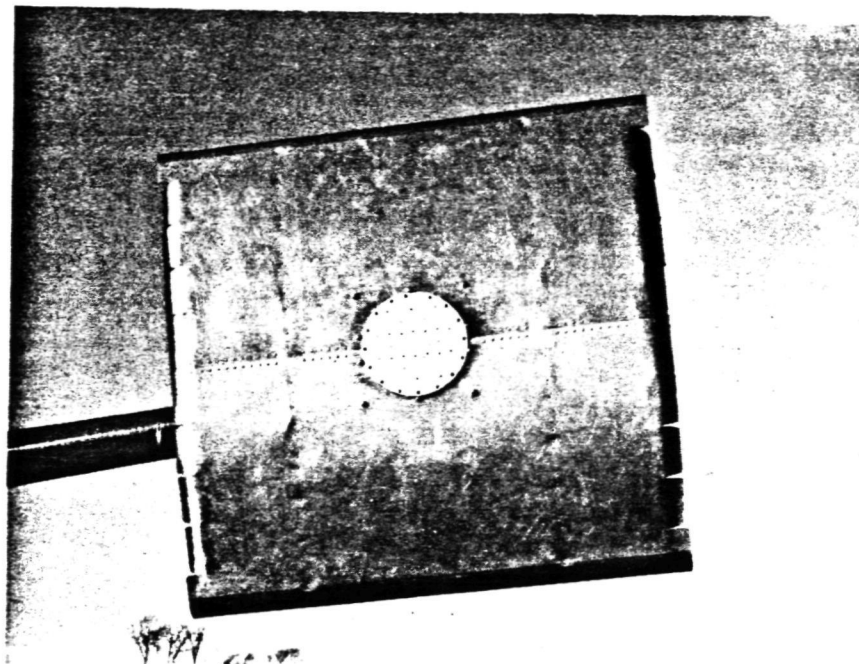


TEXAS INSTRUMENTS
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FIGURE 1. SPACS II ANTENNA ARRAY SUBSYSTEM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 4

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1207-14



FIGURE 2. SPACS II ARRAY IN GROUND PLANE TEST FIXTURE

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 5

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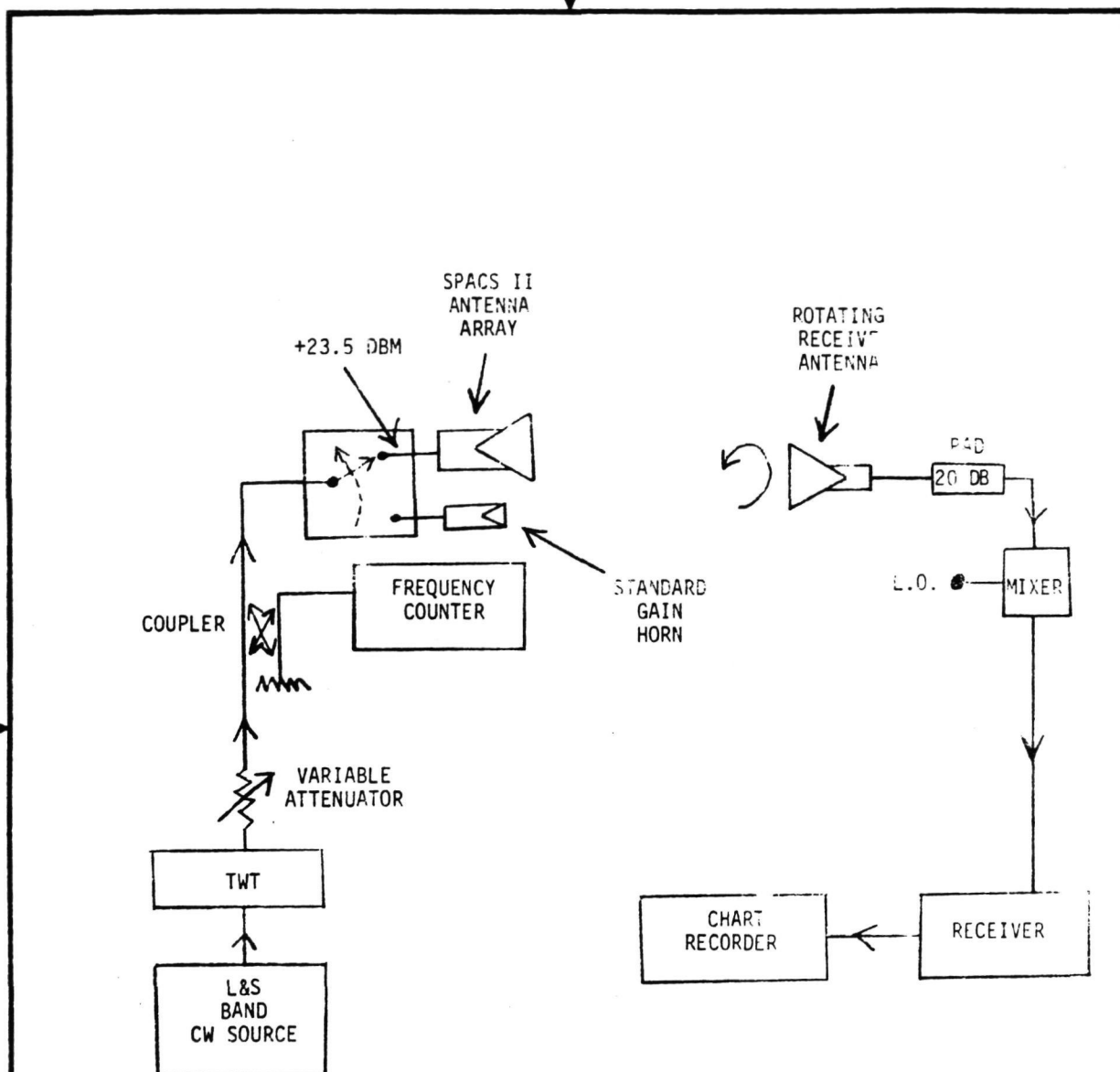


FIGURE 3. SPACS II ANTENNA ARRAY-TRANSMIT EIRP AND ANTENNA PATTERN MEASUREMENT

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 6

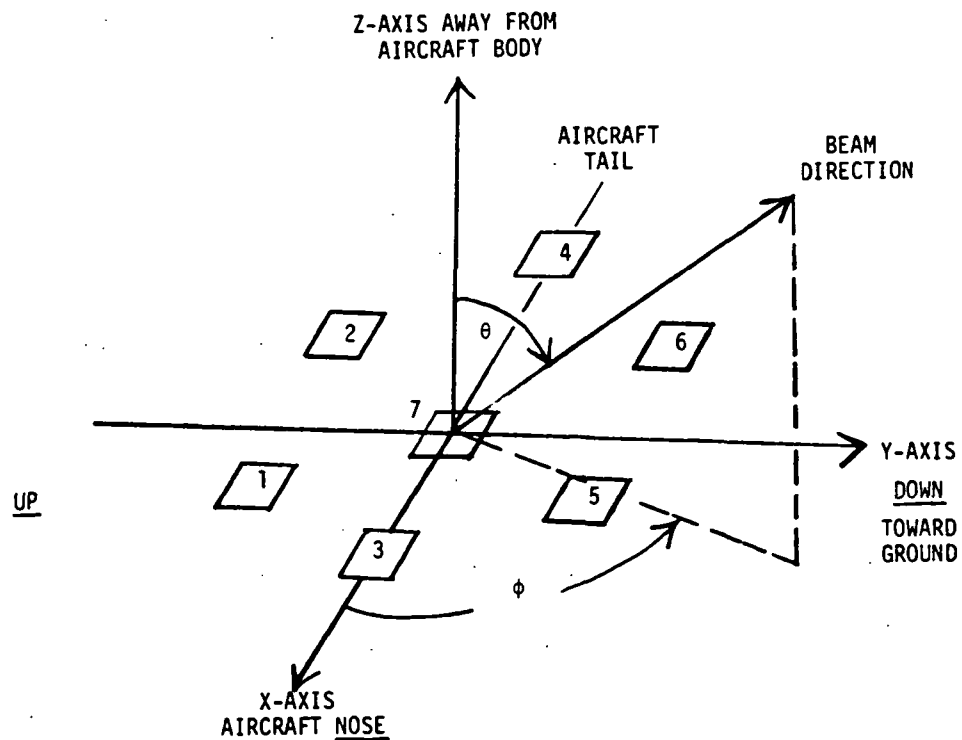


FIGURE 4. SPACS II ANTENNA ARRAY STEERING GEOMETRY AND COORDINATES

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET
		7

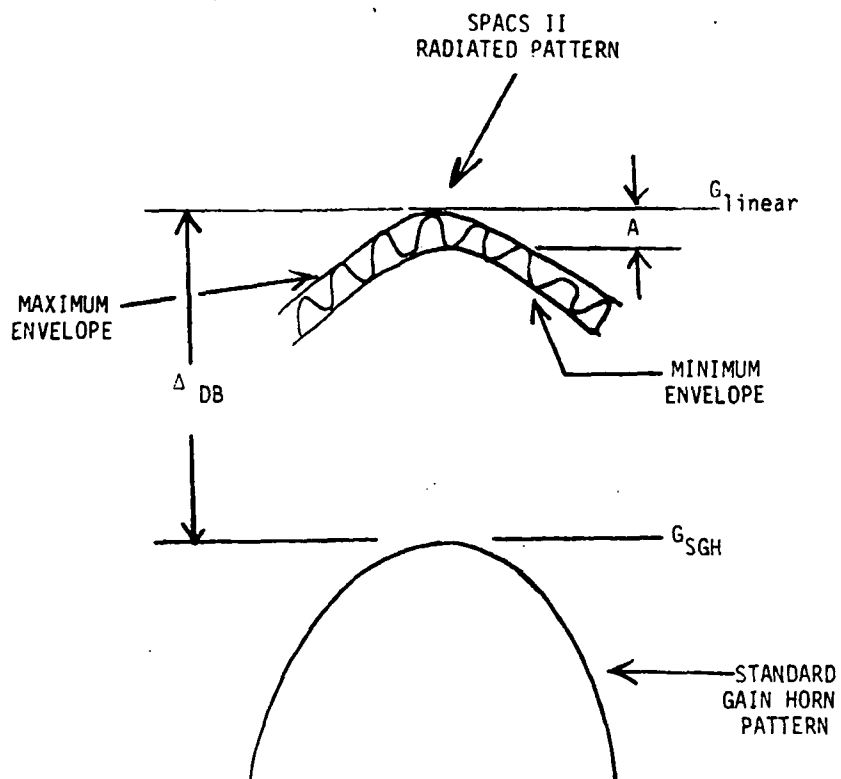


FIGURE 5. SPACS II ANTENNA ARRAY-EIRP/GAIN MEASUREMENT TERMINOLOGY

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 8

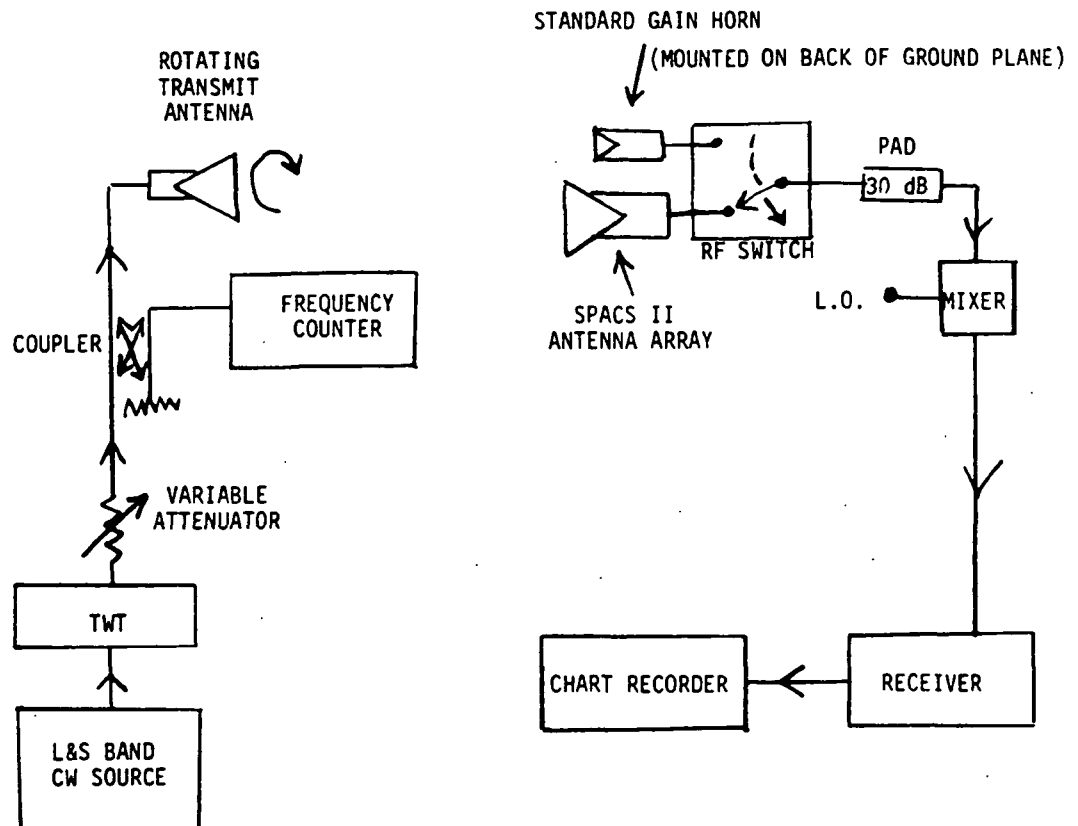
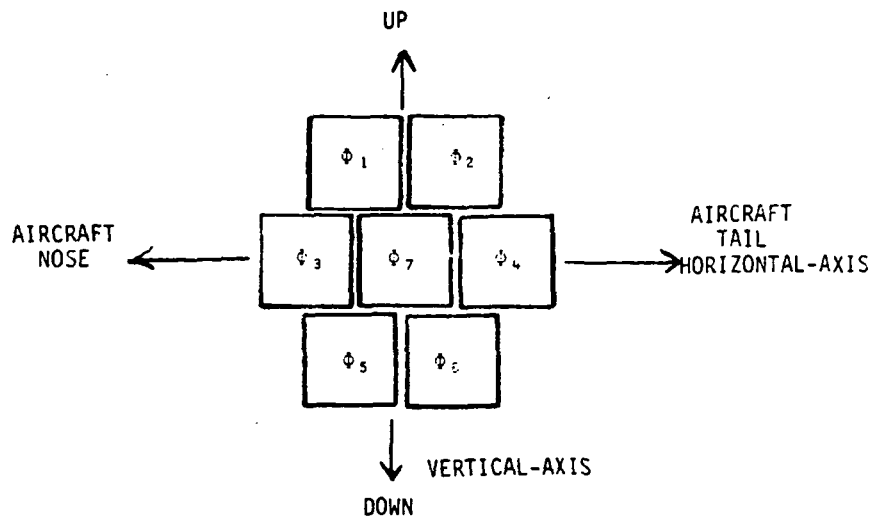


FIGURE 6. SPACS II ANTENNA ARRAY-RECEIVE GAIN AND ANTENNA PATTERN MEASUREMENT

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 9



TABLE 1. MODULE PHASE SHIFTER SETTINGS FOR REQUIRED ANTENNA
SCAN MEASUREMENTS



ARRAY		COMMANDED MODULE PHASE SHIFTER POSITIONS						
SCAN POSITION	PEAK OF BEAM SCAN ANGLE	Φ_1	Φ_2	Φ_3	Φ_4	Φ_5	Φ_6	Φ_7
A.	HORIZONTAL PLANE	-	-	-	-	-	-	-
1	0°	0°	0°	0°	0°	0°	0°	0°
2	25°	45°	315°	90°	270°	45°	315°	0°
3	48°	90°	270°	180°	180°	90°	270°	0°
B.	VERTICAL PLANE	-	-	-	-	-	-	-
1	0°	0°	0°	0°	0°	0°	0°	0°
2	25°	90°	90°	0°	0°	270°	270°	0°
3	38°	135°	135°	0°	0°	225°	225°	0°

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 10

TABLE 2. SPACS II ANTENNA ARRAY-FREQUENCIES AND
PLANES OF CUT FOR ANTENNA TRANSMIT
PATTERN MEASUREMENTS

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	FREQUENCY (MHZ)	ϕ PLANE OF CUT (DEGREES)	MEASUREMENT SCAN ANGLE (DEGREES)
A.	HORIZONTAL PLANE	-	-	-
1	0°	2217.5 2287.5	0° 	ON-BORESIGHT ON-BORESIGHT
2	25°	2217.5 2287.5		35 35
3	48°	2217.5 2287.5		70 70
B.	VERTICAL PLANE	-	-	-
1	0°	2217.5 2287.5	90° 	ON-BORESIGHT ON-BORESIGHT
2	25°	2217.5 2287.5		25 25
3	38°	2217.5 2287.5		50 50

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 11

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TABLE 3. SPACS II ANTENNA ARRAY-EIRP MEASUREMENTS AT
TRANSMIT FREQUENCIES*

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	ϕ PLANE OF CUT (DEGREES)	SCAN ANGLE FOR EIRP (DEGREES)	G _{SGH} (DB)	Δ _{DB}	A (DB)	B (DB)	G _{CP} (DB)	EIRP DBW
A.	Azimuth HORIZONTAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2217.5 2287.5	0°	BORESIGHT BORESIGHT	16.28 16.46	10.8 10.0	0.2 0.2	2.9 2.9	30.0 29.4	23.5 22.9
2	25°	2217.5 2287.5	↓	35 35	16.28 16.46	9.2 9.0	0.8 0.1	2.65 2.95	28.1 28.4	21.6 21.9
3	48°	2217.5 2287.5		70 70	16.28 16.46	6.5 5.6	4.7 3.2	1.25 1.70	24.0 23.8	17.5 17.3
B.	Roll VERTICAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2217.5 2287.5	90°	BORESIGHT BORESIGHT	16.28 16.46	11.0 10.0	0.2 0.4	2.9 2.8	30.2 29.3	23.7 22.8
2	25°	2217.5 2287.5	↓	25 25	16.28 16.46	9.0 9.4	0.1 0.5	2.95 2.95	28.2 28.6	21.7 22.1
3	38°	2217.5 2287.5		50 50	16.28 16.46	7.5 7.1	0.7 0.8	2.7 2.65	26.5 26.2	20.0 19.7

*NOTE: INPUT POWER TO ARRAY IS -6.5 DBW (+23.5 dBm)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 12

TABLE 4. SPACS II ANTENNA ARRAY-FREQUENCIES AND PLANES OF CUT FOR
ANTENNA RECEIVE PATTERN MEASUREMENTS

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	ϕ PLANE OF CUT (DEGREES)	MEASUREMENT SCAN ANGLE (DEGREES)
A.	HORIZONTAL PLANE	-	-	-
1	0°	2041.9 2106.4	0° ↓	ON-BORESIGHT ON-BORESIGHT
2	25°	2041.9 2106.4		35 35
3	48°	2041.9 2106.4		70 70
B.	VERTICAL PLANE	-	-	-
1	0°	2041.9 2106.4	90° ↓	ON-BORESIGHT ON-BORESIGHT
2	25°	2041.9 2106.4		25 25
3	38°	2041.9 2106.4		50 50

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 13

TABLE 5. SPACS II ANTENNA ARRAY-GAIN MEASUREMENTS AT
RECEIVE FREQUENCIES*

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	PLANE OF CUT (DEGREES)	SCAN ANGLE FOR G _{CP} (DEGREES)	G _{SGH} (DB)	Δ _{DB}	A (DB)	B (DB)	G _{CP} (DB)	RCVR LINEAR OUTPUT LEVEL (DBM)
A.	Azimuth HORIZONTAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2041.9 2106.4	0°	BORESIGHT BORESIGHT	15.76 15.93	21.2 19.7	0.2 0.1	2.9 2.95	39.9 38.6	+10.0 +12.1
2	25°	2041.9 2106.4	↓	35 35	15.76 15.93	19.8 18.4	0.4 0.4	2.8 2.8	38.4 37.1	+9.8 +11.5
3	48°	2041.9 2106.4	↓	70 70	15.76 15.93	17.8 16.2	8.0 6.0	0.65 1.0	34.2 33.1	+9.6 +11.1
B.	Roll VERTICAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2041.9 2106.4	90°	BORESIGHT BORESIGHT	15.76 15.93	21.0 19.7	0.1 0.8	2.95 2.65	39.7 38.3	+10.3 +12.2
2	25°	2041.9 2106.4	↓	25 25	15.76 15.93	20.0 19.1	0.4 0.2	2.8 2.9	38.6 37.9	+9.5 +11.0
3	38°	2041.9 2106.4	↓	50 50	15.76 15.93	17.8 16.0	0.8 0.8	2.65 2.65	36.2 34.6	+10.0 +11.5

*NOTE: LINEAR RCVR OUTPUT IS FOR LESS THAN 1 DB RECEIVER GAIN COMPRESSION

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APPENDIX

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD401	
SCALE	REV	SHEET	15

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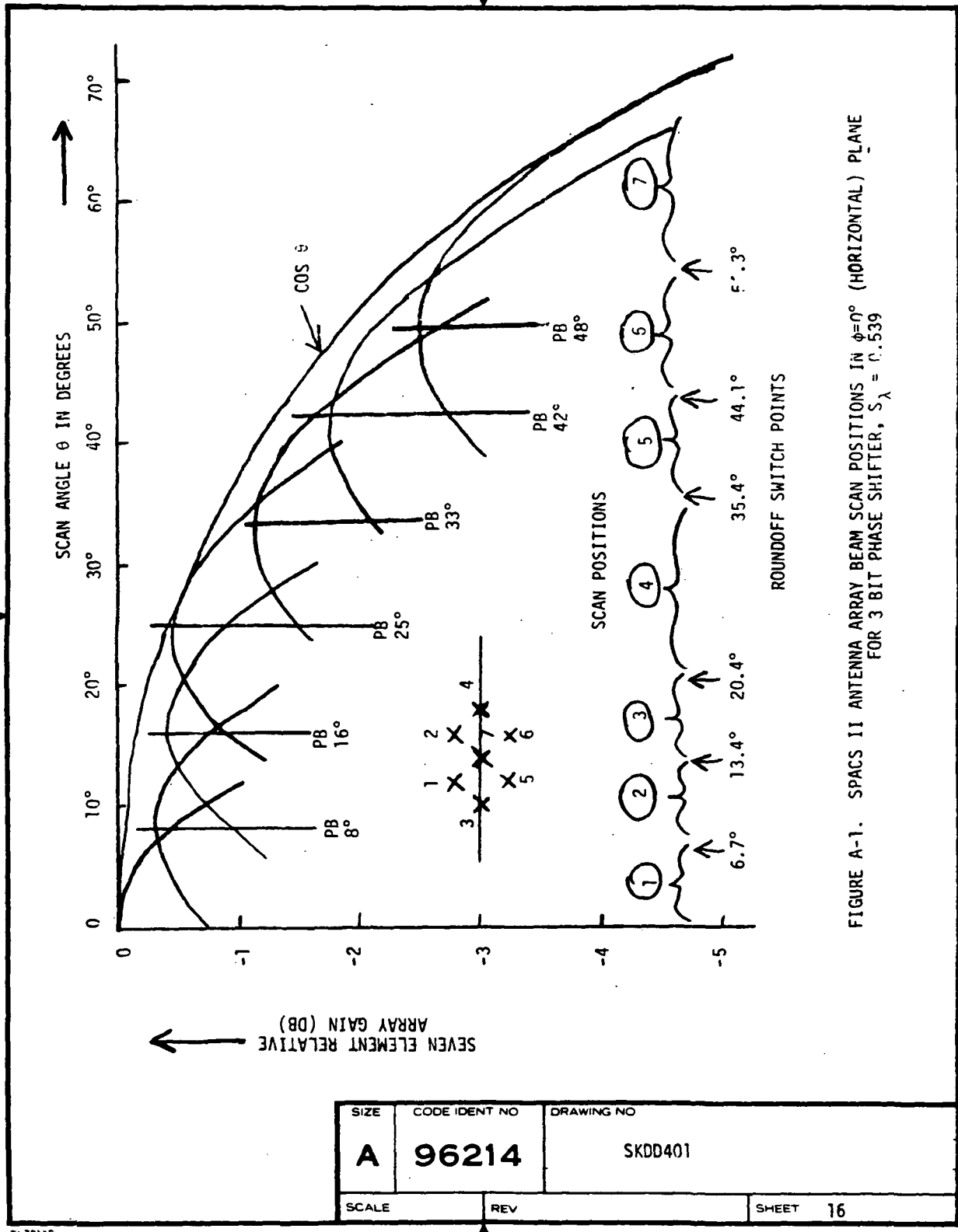


FIGURE A-1. SPACS II ANTENNA ARRAY BEAM SCAN POSITIONS IN $\phi=0^\circ$ (HORIZONTAL) PLANE FOR 3 BIT PHASE SHIFTER, $S_\lambda = 0.539$

E-16

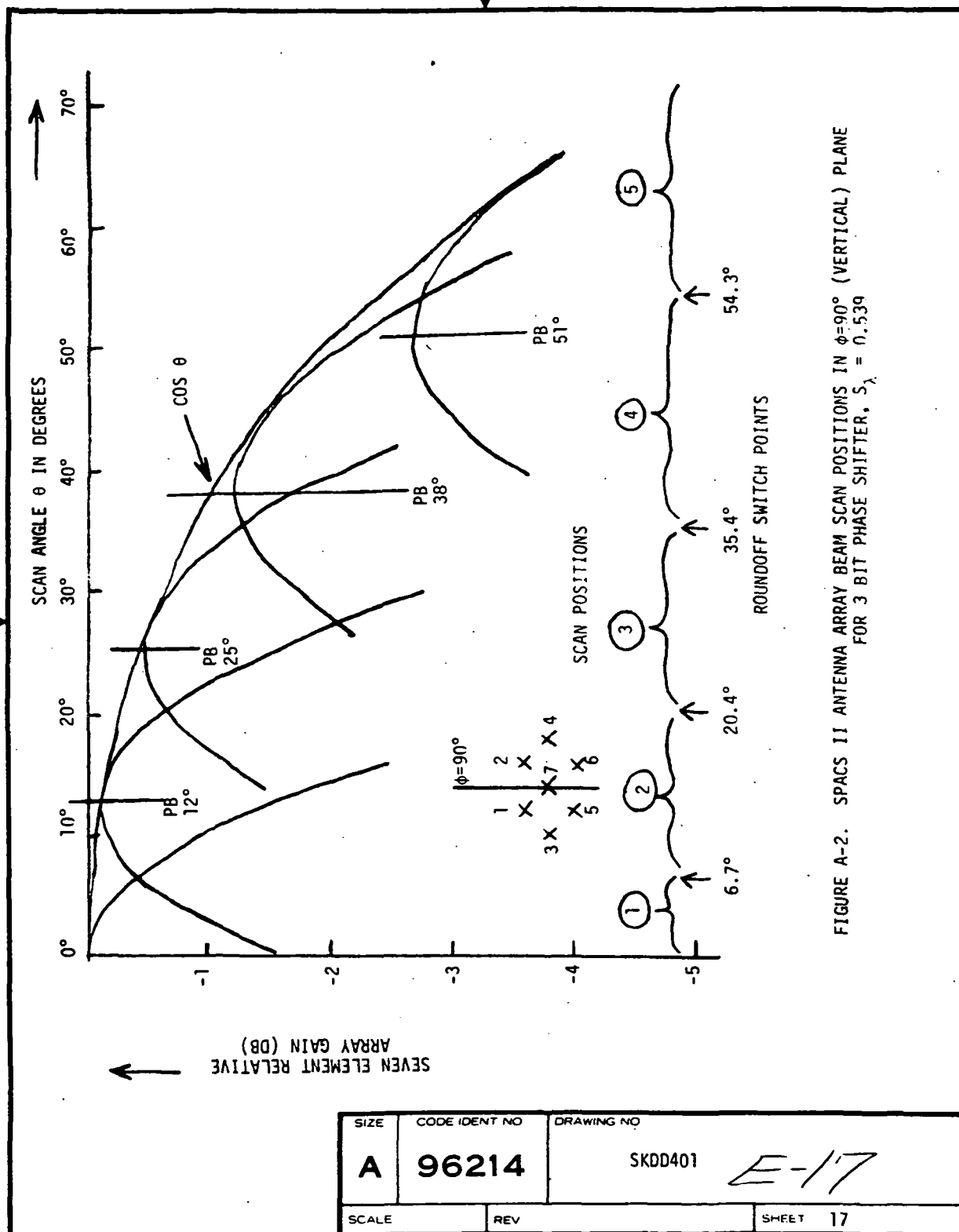


FIGURE A-2. SPACS II ANTENNA ARRAY BEAM SCAN POSITIONS IN $\phi=90^\circ$ (VERTICAL) PLANE FOR 3 BIT PHASE SHIFTER, $S_\lambda = 0.539$

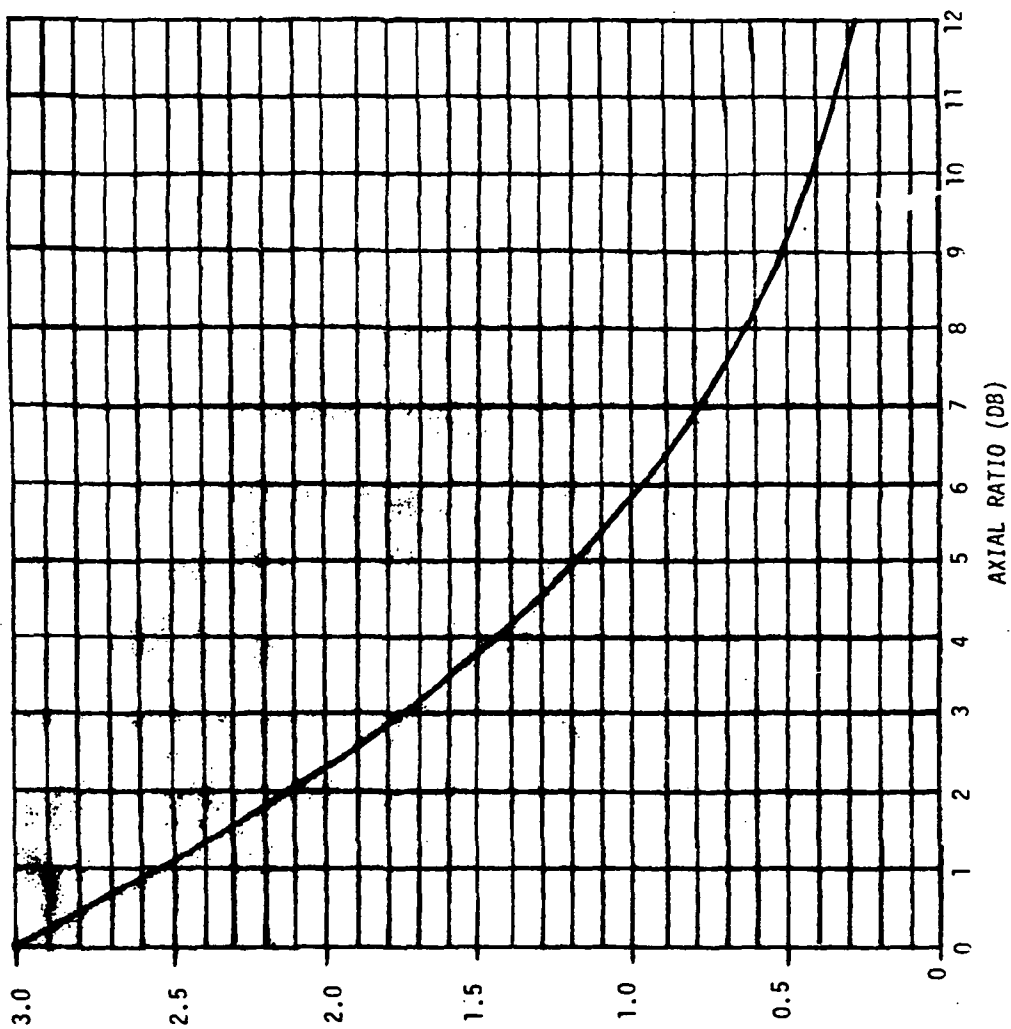


FIGURE A-3. MATCHED POLARIZATION GAIN CORRECTION FACTOR

CORRECTION FACTOR (DB) :
MATCHED POLARIZED REFERENCE

SIZE A	CODE IDENT NO 96214	DRAWING NO SKDD401	<i>E-18</i>
SCALE	REV	SHEET	18